LEVEL II

1

# Environmental Study Plan

# for the

# Trinity River Basin

# Texas

AD A097242

environment consultants, inc.

Submitted to

U. S. Army Corps of Engineers

Fort Worth District

April, 1972

Contract No. DACW63-72-C-0033







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The study plan in this report outlines the framework for a comprehensive environmental study of environmental conditions within the Trinity River Basin, in order to evaluate the environmental impact of the Trinity River Project. The planned research will concentrate on the investigation of natural processes and components present in the environment, the overlay of human activities on the natural system, and the effect of planned changes on both natural and human conditions existing within the basin. The proposed

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20. study is divided into four stages. Stage One involves an inventory of resources existing within the Trinity River Basin. Stage Two involves an intensive investigation and evaluation of the more significant areas to be affected by the project. Stage Three involves preparation of a mathematical model to synthesize information obtained during phases one and two. Stage Four involves preparation of the required environmental impact statement. In summary, the study plan has as its basic goal the investigation of natural processes and components present in the environment and consideration of feasible future changes.

# Environmental Study Plan

for the

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April 19, 1972

Contract No. DACW63-72-C-0033



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ABSTRACT

In order to respond to the specifications and spirit of the National Environmental Policy Act of 1969 it has been proposed that a comprehensive study be undertaken of environmental conditions within the Trinity River Basin, in order to evaluate the environmental impact of the Trinity River Project.

An outline of such a study is presented in this report. The planned research will concentrate on the investigation of natural processes and components present in the environment today, the overlay of human activities on the natural system, and the effect of planned changes on both natural and human conditions existing within the basin.

Central to the study is the use of an interdisciplinary team of environmental scientists who will obtain a broad understanding of the flow and pathways of energy and materials through the hydrological, biological and economic systems of the Trinity watershed. This team of generalists will <u>first</u> map the existing resources of the basin, and supervise development of sophisticated computer models capable of simulation of processes and activities within the basin.

The <u>second</u> stage of the study will involve the deployment of a task force of specialists who will make detailed surveys of basin resources, environmental characteristics, and possible future conditions in the basin. At this time project design and basin management will be considered and alternatives to the project will be identified.

The <u>third</u> stage of the study will concern synthesis of the vast amount

of information gathered in the first two parts of the study, and the interpretation of detailed computer modeling of basin environments, including ecological responses to project components. During this stage it will be possible to generalize about optimum land-use patterns within the basin, and to evaluate the Trinity Project (and other plans) in terms of these patterns. Project economics will be considered, and it is expected that there will be major inputs into project designs and basin management programs.

The fourth stage of the study will involve preparation of the environmental statement required by law, so that responsible citizens and government agencies can evaluate the project using reliable scientific information. Continued basin monitoring and in-depth analysis of problem areas should follow completion of the research outlined here.

The products of the environmental study will include:

1. A baseline inventory of processes and materials occurring in the watershed in order to permit evaluation of future changes; basin ecosystems, hydrodynamics and socio-economic structures will all be evaluated.
2. Mapping which shows natural regions within the basin, indicating units to be used for planning purposes, and showing locations of valuable resources;
3. Computer models capable of adaptation to changing conditions within the basin, and useful hereafter in project design and basin management;
4. A framework for future environmental studies in order to permit continued improvement of management of resources within

the basin, especially water and human resources;

5. An established procedure for preparation of environmental impact statements required for any major project within the basin, and a compendium of background information to be used in the statements.

In summary, the proposed study will provide a nucleus for all subsequent environmental research within the basin, and will lead toward the goal of ecological soundness in Trinity River planning. The study will be the most extensive interdisciplinary research yet attempted for assaying predevelopment conditions in a major drainage basin, and the effect of a river basin project on the environment. As such the study should prove to be a model for future research on river systems in the United States, and for interpretative analyses of ecosystems everywhere.

## PREFACE

The study plan given in this report outlines the framework for a comprehensive environmental survey of a complete large drainage basin following standards set by Public Law 91-190 (National Environmental Policy Act). The proposed research aims to fully catalogue environmental impacts to be expected from the Trinity River Project, insofar as present knowledge permits, and thus will be one of the most extensive single environmental research projects yet undertaken in the United States.

The difficulties and importance of environmental research have been well expressed by Lt. General Frederick J. Clarke, Chief of the Army Corps of Engineers. General Clarke has stated that "we find a need for a professional ethic in the environmental field so that the public can have a mechanism other than the courts to separate out the fringe elements, and have the benefit of the weight of opinion of professional environmentalists". The study plan presented here is designed to provide the professional opinions that are so necessary to project planning. General Clarke has also noted that environmental research is designed not to impede the progress of a project. Rather "the environment must be considered - honestly and as objectively as possible...(the law) does not say that a project or proposal cannot go ahead if there are environmental disadvantages. But it does say that there shall be a full consideration of alternatives and mitigating measures before the decision is made to go ahead".

The proposed study involves the use of a large number of highly qualified professional environmental scientists, with logistical support over a period of 24 months. The magnitude of this research is more than matched by the benefits to be derived from it, for the study will provide a framework for all subsequent environmental analyses and development planning in the entire Trinity Basin. Just as the Trinity River Project aims to be "a model of environmental and ecological soundness" (David Brune, 1972), so this study plan aims to be a model for environmental research throughout the nation.

Because the study will be the first thorough inquiry into environmental conditions in a large basin, and because the concept of "environment" used here is very broad, the study plan stresses fundamental concepts to be followed in structuring the investigations. Specifications are given with sufficient precision to permit scheduling of the work, approximate budgeting of time and funds, identification of personnel and equipment needs, and establishment of lines of command. However the study plan does not exhaustively detail research procedures, in order to maintain flexibility in execution of study programs

Programs already underway, whether by government agencies, academic institutions, the Trinity River Authority, or concerned citizens groups, should be integrated into the study whenever possible. However these programs, contingent upon their quality, must be arranged to fit within the framework presented here, if full value is to be obtained from their efforts.

Participation by outside agencies and organizations may lower the total cost of the proposed investigations, and may permit an acceleration in scheduling of study activities. In any case the projected cost of the research is small in comparison to benefits received from the study; and the projected length of the research is small in comparison to the lifetime of environmental benefits which should be derived.

However, the study must not be permitted to become a series of semi-independent efforts which when completed will provide more questions than answers. To this end it is particularly important that considerable effort be expended on selection of the team of scientists who will provide the interdisciplinary supervision of the research. These scientists should work full time on the study, and should not have additional responsibility to other government agencies or academic institutions.

If the program of research outlined in this report proves successful then the Trinity River Basin can be developed in a manner that will best serve all the people and thus provide a better life for the citizens living within the watershed.

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# NATURE OF THE STUDY PLAN

## A. Introduction

The study plan in this report has been prepared with full consideration of the purposes of the National Environmental Policy Act of 1969 (NEPA, Public Law 91-190) as specified under Sec. 2. These purposes are to "encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation".

The studies outlined in this report will produce data and information regarding the proposed Trinity River Project to assist the Fort Worth District Corps of Engineers in complying with the requirements of NEPA, as specified in Sec. 102. These requirements include the utilization of "a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment" in the Trinity River Basin. Further, the studies to be performed, as outlined in this report, will lead to the required detailed statement concerning:

"(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed actions should it be implemented."

It must be emphasized that these studies are intended not only to provide information required for the necessary environmental statement, but also to furnish input in the design stages of the Trinity River Project. This input will permit the project to be designed to minimize environmental damage within the basin, and to enhance the environmental quality of the basin as far as possible.

The plan submitted here presents the environmental analysis prescribed by NEPA. The difficulties of preparing such an analysis have been well expressed by Lt. General Frederick J. Clarke, Chief of the Army Corps of Engineers. General Clarke's comments are directly appropriate to this study plan and are given in Appendix K.

It is recognized that components of this study may be conducted by other government agencies, local sponsors of the project, independent groups, or by individuals not directly supervised by the Corps. However, since ultimate jurisdiction and responsibility lie completely with the Fort Worth District, coordination of activities performed by out-of-house groups will present scheduling problems. In that event, it may not be feasible to meet time-requirement projections given here, and progress should be periodically updated. A schedule for monitoring this progress and making updated completion projections is therefore included (Appendix F).

B. Basic approach of the proposed study.

The proposed study is divided into four stages:

Stage One. The initial stage involves an inventory of resources existing within the Trinity River Basin. This stage includes the development of a matrix for computer-storage of data, and the development of mathematical models for simulating flows of material and energy through the watershed. Remote sensing imagry and field investigation will be used to map the natural resource regions within the basin.

Stage Two. The second stage involves an intensive investigation and evaluation of the more significant areas to be affected by the project -- in particular the hydrologic, ecologic and water quality characteristics of the river system and the socio-economic structures of the region. This stage includes the full exploration of alternatives to the project, as required by NEPA.

Stage Three. The third stage involves a synthesis of information obtained during phases one and two. The mathematical model will be used to assist in prediction of the environmental impact of project components -- i.e., changes in flow of energy and material through the basin and changes in structure of basin ecosystems. The model will also assist in prediction of the consequences of the possible alternative actions. Stage three will provide the input for design planning so that harmony between the project and the environment can be achieved.

Stage Four. The final stage of the project will involve preparation of the required environmental statement and the implementation of a framework for continued environmental surveillance and design inputs as the project develops.

As specified by NEPA, the nucleus of the study should be an interdisciplinary team of environmental scientists (see discussion in Stage One, part D). These scientists will be required to work full-time throughout the life of the study, with considerable periods spent in the field. Furthermore these scientists will be required to supervise and interact with many specialists who will be engaged in more detailed studies. The interdisciplinary team, made up of generalists, should be out-of-house in nature, although under direct supervision of the Fort Worth District.

It is vital to recognize that the orientation of the entire study project is quite different from the customary approach utilized by many research specialists. Some of these differences are discussed below.

1. The study is not intended to develop new scientific concepts. Of course, such conceptual developments would be a welcome by-product of the study. Indeed, the gathering and interpretation of comprehensive data on a single river system is likely to lead to considerable advances in man's understanding of his environment, and the effects of his actions on that environment.
2. While the study will rely on the latest information and

methodology available from the environmental sciences, this expertise will not be strictly applied along lines specified by traditional disciplines. Rather the study must involve full integration of each aspect of the environmental sciences. The interactions of all basin ecosystems will be explored, rather than the isolated components of ecosystems as are traditionally studied. Successful analysis of the basin environment thus requires that those supervising the research have a profound interdisciplinary understanding of natural processes.

3. The study is neither an exercise in taxonomy nor in the collection and cataloging of data. Rather it is an effort to understand the on-going physical, chemical, and biological processes in the basin. Such an understanding is needed in order to anticipate the extent to which these processes have been and can be modified by man. The resource inventory is oriented toward understanding the resources in terms of an overall environmental structure, and toward understanding of that overall structure.

In summary, the study plan has as its basic goal the investigation of natural processes and components present in the environment today and consideration of feasible future changes.

## FIRST STAGE:
## ACQUISITION OF BASIC ENVIRONMENTAL INFORMATION

The first stage of the proposed study includes four parts: literature and data search, development of computer matrix, computer modeling, and resource mapping. The objective of this stage is to obtain an overview of environmental conditions within the basin, and to prepare maps and models to be used in the more detailed investigations which will follow (stages two, three). The computer modeling and the mapping of resource units are the two essential parts of the study, without which subsequent research cannot proceed.

### A. Literature and data depository search

An early objective in the study will be to search and acquire all extant information concerning the environment of the Trinity River Basin. This search will involve analysis of library collections, government and non-government data gathering projects, and similar sources. Emphasis in the search will be on the following:

1. Descriptive literature on environmental conditions in east Texas - geology, hydrology, water quality, pedology, ecology, archaeology, land use and planning, economic and social conditions, aesthetics.
2. Quantitative information on environmental conditions in or near the Trinity basin - climate, hydrology, vegetation, wildlife and fishery resources, economics.

3. Mapped information on environmental conditions in or near the Trinity Basin, including maps of land-use patterns.

4. Remote sensing imagry interpretation within the basin area, particularly in floodplain regions - air photography, infrared and color infrared surveys, thermal, radar, multispectral, and other applicable imagry.

5. Development projects proposed or under way within the basin, and the history of past development, especially the environmental consequences of same. Existing regional plans and zoning regulations will be determined.

6. Detailed characteristics of all components proposed under the Trinity River Project, and characteristics of other projects, such as implementation of conservation practices.

7. Status of environmental research, including control technology, specifying problems known to concern government agencies, permitting boards and responsible citizens groups.

B. Development of matrix for computer-storage of information

It is anticipated that the proposed thorough evaluation of environmental conditions within the Trinity Basin will result in the production of much data. Optimum use of the data requires that storage, classification, and retrieval of the information be made simple and rapid. Use of computer systems for data handling are worthwhile only when the systems permit complete flexibility in use and display of the stored information. Data not to be used in modeling need not necessarily be digitized for storage.

The specific goal of this part of the study will be to formalize a system for digitizing data and storing it within a matrix indexed to actual geographic locations within the study area. The needed research will focus on the expected characteristics of the data, and the primary data handling required. Particular emphasis will be placed on establishing a grid system in which the cell size can be adjusted to conform with the needed degree of sensitivity in any area. For example data storage for the basin as a whole might be done using a point spacing of one mile, whereas along flood-plains point spacing may be 1/4 mile or less.

All data processing procedures, including the models described below, must be fully documented before stage three of this study is initiated.

C. Development of mathematical models.

A major problem of the proposed study is that it is difficult to fully comprehend the intricacies of a river system as large as the Trinity. A partial solution to this problem is to use computer methodology in order to permit handling of the vast amount of information which will be acquired. Computer techniques for data processing have the advantage of permitting a very large memory unit to be used for storage, as well as providing extremely rapid access to and manipulation of the data. A well structured system permits continued updating of the information bank as the basin environments undergo natural and induced changes.

Computer techniques, in order to be truly helpful, must involve a valid model to be used in data analysis. An inadequate model can result in serious misinterpretations and disasterous planning. Only very careful and thorough development of a model, using the human mind, will ultimately permit useful data processing.

At the outset of the study plan, therefore, development of the computer model will begin, with the goal of using the model to simulate environmental interactions within the basin. The model will continue to be developed throughout the lifetime of the study, and thereafter.

Conventional models of natural systems are not adequate for a project as complex as the Trinity River development. Most available models are rather narrowly constructed and refer to only one specific aspect of the environment. A typical model would be one used to predict flood peaks resulting from characteristic storm events.

The models used in the Trinity River study must depart from such narrow considerations. The entire orientation of the study must be toward interdisciplinary analysis of the environment. The model must integrate many sub-models representing different interdependent components of the environment. Only this type of model will adequately reflect the philosophy of NEPA,and avoid the types of challenges which have been effective in stopping other river basin projects.

Furthermore, the model must show the interrelationships existing between various parts of the system, so that the structure of the entire basin can be analyzed. The model must permit input of simulated actions concerning basin development or management. Specific capability is required to permit simulation of the construction of each project component, as well as simulation of completion of the entire project.

Thus the proposed model will have subcomponents in which much of the input consists of information generated by other subcomponents. In turn output from each part of the model will be fed into other parts of the model, just as in nature the output from one ecosystem or tributary basin can flow to or through another.

The basic structure of the model should begin with climatic considerations and carry through to the physical, chemical and biological conditions on the earth's surface. The model will consider flows of material and energy from the atmosphere and earth, through and over the soil and biosphere, and into the hydrologic components of the system. Special attention will be given to the aquatic ecosystems as functions of adjacent and upstream conditions. For example the condition of the estuarine ecosystem in Trinity Bay must and will be related to the differential summation of nutrient energy and water resources in the entire basin.

The modeling will require further expansion so that changes in the environment can be considered. In particular the model should generate information on the environmental consequences of each part of the Trinity River Project. Implementation of the model should permit design changes for the purpose of environmental enhancement. The basic model will not consider aspects of the environment (e.g. social, recreational, sceni or archaeologic values) which do not represent natural flows of energy or material through the system. However, additional simple models of the economic structure and planning strategies in the basin will be developed, in order that the importance of these can be considered.

D. Environmental Resource Mapping.

The actual inventory of the existing environment is done first on a regional scale. The environment is a well-structured system of definable components - rocks, water, soils, biota, climate. Only human activity in the environment is poorly structured or disordered with respect to other activities.

Each part of the landscape consists of a specific assemblage or pattern of rocks, soils, hydrologic processes, biota. A part of landscape with similar patterns is called an Environmental Resource Unit, or ERU. An ERU may be a physical unit, found in a given geological environment. The Black Prairies of Texas, found on Cretaceous clays and shales, are an ERU because they have a very specific pattern of physical and biological characteristics, and can be divided into coherent sub-units. An ERU may reflect natural physical processes (e.g. a floodplain), biological processes (e.g. a marsh), or even human processes (e.g. a suburb).

Every ERU can be broken down into many sub-units. For example, within a floodplain there may be natural levees, active and abandoned channels, scroll-meander areas, and terraces at several levels. Every unit and sub-unit is a sum product of present and past processes, and in turn determines the characteristics and rates of ongoing natural processes.

The concept of an ERU is widely recognized as being crucial to understanding of the environment. Official United Nations teams engaged in mapping for development use "Land Systems" (see Wilson, 1969, reprinted in Appendix K) which are the same as ERU's. In Texas, the Bureau of Economic Geology is using the "Resource Capability Unit" (Brown, et. al, 1971) in preparing environmental atlases. Another specialized form of the ERU is used by the U. S. Army Corps of Engineers for the purpose of "terrain" classification (Van Lopik & Kolb, 1959).

ERU mapping is best done using a group of scientists working closely together. This group is designated as the Systems Coordinating and Analysis Team, or SCAT. Mapping can be done on existing air photos by the team which should include an aquatic-terrestrial ecologist, a hydro-engineering geologist, an agro-chemical pedologist, and land-use socio-economist. These titles are given to express the diversity of areas of competence that are required for the generalists of SCAT as well as to indicate the disciplines in which expertise is required. In practice the team should consist of about four individuals who encompass as many of the disciplines as possible, and who have the facility to communicate with all branches of the natural and social sciences. Field data will confirm or modify the mapping. Emphasis in the field is placed on core areas; that is, areas which are most typical of each ERU encountered. Also studied are boundary areas between ERU's and any anomalous areas found on the photos.

ERU maps, and maps of land-use, will be used extensively in the specialist research studies that comprise stage two.

Upon completion of the basic mapping, the specialist studies can be initiated. However, SCAT must be kept together in order to coordinate the more detailed studies, and in order to revise the basic mapping as detailed information becomes available. The final synthesis (stage 3) should be handled by this team, with the assistance of others, and the team should have a role in preparation of the environmental statement. The team should further be able to provide input into the environmental designs of the project.

The selection and direction of the Systems Coordination and Analysis team is a most strategic part of the proposed study, especially in light of NEPA requirements for interdisciplinary approaches which integrate the sciences. Details concerning the team are given in Appendix B.

The work of SCAT will require considerable support staff, including office, research, statistical, laboratory, cartographic, and field personnel. This staff, which can be utilized in later stages of the study as well, is discussed further in Appendix B. Logistical support for the entire study, Stages One through Four, is discussed in Appendices G and H.

## SECOND STAGE:
## ACQUISITION OF DETAILED ENVIRONMENTAL INFORMATION

Upon completion of the Environmental Resource Unit(ERU)mapping, it is important that the entire study plan be reviewed. This review will determine if information obtained by the mapping, by literature search, or by computer modeling is such as to require changes in the plan. Such changes should not be major. During this review it will be possible to make rather firm scheduling commitments for the remainder of the project, subject of course to further revisions.

Following the review, the stage involves three parts: a) the acquisition of technical data by various types of instrumentation; b) the analysis of these and other data by specialist scientists; c) the study of project alternatives. During the second stage of the study the development of computer models (begun in stage one) will be continued.

### A. Instrumentation for technical data.

Based on the analysis of acquired data it will be possible to determine aspects of the environmental structure which remain poorly known. At this time it will be necessary to budget time and money for instrumentation designed to obtain the needed data. Examples of such instrumentation include:

1. Establishment of hydrologic data stations, e.g. to sample flows, water quality, or sediment along key reaches or important (but unsampled) tributaries.

2. Establishment of stations to monitor climate, soil conditions, biological productivity or other physical, chemical or biological conditions and processes in important settings.

3. Planning of needed remote sensing imagry and high resolution air photography.

B. Analysis of data by specialist scientists.

Specialist scientists, working under the direction of SCAT, should begin at this stage to provide detailed information on the environment. These scientists are hereafter referred to as the Basin Environment Evaluation Force (BEEF). The work of the specialists is made much easier by the fact that the basic environmental structure has been determined by mapping of Environment Resource Units (ERUs).

The general role of BEEF will be to obtain detailed information on environmental conditions within the basin, as appropriate to their disciplines. Using ERU maps, it will be readily possible to ascertain where field work is most needed in order to effectively characterize the environment. For this study the primary emphasis will be on floodplain areas and areas of proposed flooding or physical modification, with secondary attention to areas which are major sources of basin materials and energy. The specialists will be expected to provide detailed information on each Environmental Resource Unit and sub-unit, to evaluate the areas affected by the project in terms of their present and possible future resource capabilities, and to provide planning input to minimize undesirable environmental impacts of the project where possible.

BEEF will utilize the expertise of over fifty professional scientists over a period of 8 - 14 months, with the longer period being required when all seasonal changes must be evaluated. The direction of the specialist studies should be in the hands of the SCAT, generalist team. During work of BEEF, SCAT will continue the effort toward obtaining a complete understanding of overall environmental conditions within the basin.

Very briefly the probable orientations of the specialist studies are characterized below. More details are given in Appendices C, D & E.

1. General geology - map bedrock geology in key areas, identifying sites of potential earth resources (e.g. fuels, construction materials, waste disposal sites).
2. Engineering geology - identification of engineering characteristics of areas slated for development by the Trinity River Project.
3. Geomorphology - surface processes, erosion, and sedimentation occurring in floodplain areas and on those slope areas which supply appreciable quantities of material affecting water quality; controls of natural and accelerated erosion.
4. Water balance hydrology - determine total water balance in various environmental conditions, including rates of runoff as a function of topography, climate, geology, soils and vegetation (land use).
5. River hydrology - determine hydrologic characteristics of main

stem and major tributaries, including long-term and flood hydrographs; evaluate effect of proposed flood control structures throughout basin and needs for additional structures.

6. Stream sediment dynamics - evaluate fluvial mechanics of solid load transport; evaluate effect of further river regulation on load transport, and bed or bank changes.
7. Groundwater hydrology - determine groundwater conditions as they affect surface hydrology; map and characterize aquifers of importance to regional water supplies; evaluate effect of proposed impoundments or diversions on groundwater.
8. Water quality - determine source areas, flow paths, and flow rates for chemical, biological, and physical components of surface water, including natural and pollutant chemical biological nutrients, temperature, salinity, and oxygen; evaluate effects of project on water quality; evaluate effects of possible regional development on water quality.
9. Climatology - determine climatic and meteorologic conditions over each part of the basin, including probabilistic aspects of future moisture and temperature conditions which determine hydrologic conditions or life functions.
10. Air quality - determine present air quality, and sources of possible contamination; evaluate affects of project on air quality, considering construction, potential industrialization, and transport systems.

11. Limnology (and oceanography) - determine existing conditions in lakes, reservoirs, and estuaries associated with the basin, as well as probable future conditions; predict environment in reservoirs to be constructed; estimate effect of project on water quality in all standing bodies of water.

12. Pedology - evaluate soil chemistry and agricultural potential of soil groups; determine soil physics as a factor in hydrology; soil conditions of importance to engineering considerations.

13. Agriculture - map and evaluate past, present, and probable future trends in agricultural land use and land values, estimate potential best use of land, and interactions of project on land use; evaluate need for erosion control and other management actions.

14. Forestry - as above, stressing forested land use.

15. Terrestrial ecology - determine structure and energy/materials flow paths through natural and semi-natural terrestrial ecosystems, especially floodplain areas.

16. Aquatic ecology - as above, for rivers, lakes, reservoirs, and estaurine areas.

17. Wildlife management - evaluate past, present, and probable future status of wildlife within the basin; identify endangered species, areas important for migration, and areas important in feeding or reproductive cycles; determine optimum procedures for wildlife management; evaluate effect of project on wildlife.

18. Fisheries management - as above, for fishery resources.

19. Recreation - determine present status of recreation facilities and needs in area; evaluate effect of project on recreation, and effect of recreation on environmental quality; consider status of national forest land and possible wilderness areas.

20. Archaeology - locate and evaluate archaeologic sites endangered by project activities.

21. Historical and scenic sites - determine historical and scenic land values in areas subject to modification by project; emphasize unique terrain conditions, unusual or valuable ecosystems, and open spaces.

22. Water supply and use - determine present and future water needs which may or will be met from Trinity Basin; consider proposed inter-basin transfers; evaluate project in terms of water supply and water quality.

23. Construction - determine sources of construction material needed for project components; locate areas of possible cut or fill; evaluate effects of spoil emplacement.

24. Dredging - determine likely magnitude and location of dredging, and evaluate effects of spoil emplacement.

25. Waste disposal - determine present and probable future magnitude of disposal of sewage and solid waste within basin; consider possible disposal sites, effects of project on waste magnitude and disposal, and effects of waste on basin environmental quality;

consider technological changes in waste processing, especially those involving reuse of materials.

26. Public health - determine health hazards in basin; consider role of project on vector populations and on water toxicity; evaluate role of environmental planning in improving health conditions.

27. Regional planning - determine trends in land use in area, especially urban, surburban, and industrial uses; evaluate relative effects of project on regional development; assess value of land altered by project.

28. Economics - determine economic trends in area, with and without the project; emphasize economic structure resulting from the project, including costs and benefits.

29. Transport - analyze regional traffic patterns at present and in future, with and without project; evaluate effect of increased traffic on air and water quality.

30. Law and administration - evaluate nature of governmental bodies which effect the basin, especially regulatory bodies; evaluate proposed administrative structure associated with project, including ability to respond to environmental regulations.

31. Sociology - determine past, present, and probable future social structures and cultural patterns; evaluate effect of project on these patterns, and value to society as a whole.

32. Project planning and basin management - compile information

on details of Trinity River Project; investigate proposed format of basin management, including water releases for flood control, water supply, and navigation purposes; evaluate procedural mechanisms for protection of environments, prevention of damage due to pollution, and for planning for environmental enhancement.

In addition to the above, the specialist studies may require more detailed investigations of highly technical subjects, e.g. the effect of further river regulation on shore conditions near Trinity Bay.

The vast amount of information obtained by the specialists will be stored in the computer matrices, analyzed according to ERU, and otherwise assimilated into the study.

C. <u>Study of Project Alternatives.</u>

A vital part of stage two is to evaluate the possible alternative actions which might be substituted in whole or in part for all or part of the Trinity River Project. The alternatives will at least include the following: reversion of sparsely populated areas to natural conditions; permitting the area to develop with no planning; development of the basin along plans differing in purpose from that of the project.

Analysis of these alternatives will follow the same path as that of the project itself. This means that the environmental considerations, including cost-benefit ratios, will be studied.

## THIRD STAGE:
## SYNTHESIS AND MODELING

As the specialist information becomes available it will be necessary for SCAT to integrate the information and to develop a good qualitative synthesis in which environmental conditions within the basin are considered. At this stage it will also be necessary to simulate basin development using the computer model. The resulting information, from the qualitative synthesis, and quantitative modeling, will permit the input of environmental considerations to project planning and design.

### A. Qualitative synthesis

The Systems Coordinating and Analysis Team will be responsible for developing a qualitative synthesis of environmental information obtained through the study. The synthesis should lead to an understanding of each ERU and sub-unit. The ERU structural characteristics (terrain, soils, hydrology, biota) can be fully mapped, and the spatial relationships of major environmental components displayed. From the ERU maps many special maps can be obtained - e.g. slope, erosion, soils, land use, and plant types. The basic map units will be related to overall environmental characteristics, however, rather than specific criteria. For example, mapping of vegetation sub-units will be based as much on soil and hydrologic conditions as upon floral distributions.

The synthesis will also involve the establishment of flow diagrams which evaluate processes active in each ecosystem. These diagrams will show flow pathways and rates for energy and material as they are transported through the system. Much flow will be purely physical (e.g. runoff), but some will be chemical (e.g. soil reactions). Of great importance will be flows from primary trophic levels upwards through the biological communities.

The most practical result of the qualitative synthesis will be to evaluate optimum land uses for each ERU. Some ERU or sub-units will be identified as areas which have resource values worthy of protection or exploitation. Other units will be identified as having resource limitations or hazards, e.g. due to soil problems, access, or other factors. Some units will show greater flexibility for development than others.

The land uses resulting from the completed Trinity Project will be compared with these optimum land uses. Similarly, land uses resulting from alternative development will be compared to the optimums. In this way, the Trinity Project can be evaluated as to its relative effect on the environment. The comparisons will, of course, emphasize environmental factors, but benefit-cost ratios will be given consideration.

In summary, the qualitative synthesis will involve evaluating the environmental implications of the project in terms of its effect on existing environmental conditions, and in terms of its role toward realizing the land use potential of the basin.

B. Quantitative modeling.

The purpose of the computer will be to supplement the qualitative synthesis by giving quantitative meaning to many of the environmental values, and by permitting the rapid simulation of diverse possible changes in the future basin environments.

The modeling will simulate each project component as well as alternative developments. Special attention will be paid to the hydrologic and biologic consequences of each action. In this way it will be possible to identify quantitatively any environmental problems which can be expected to result from the project.

At this stage of the study, the basic requirements of NEPA will have been satisfied, except for formal preparation of the required statement. Specifically the study will have outlined the environmental impact of the proposed action, and will have determined if any adverse, unavoidable environmental effects can be identified. The alternatives will have been evaluated, including short-term and long-term uses, with emphasis on maximizing the long-term productivity of the basin. Decision-making bodies will have information with which to evaluate merits of the proposed actions.

C. Input to project design.

As the qualitative synthesis and quantitative modeling proceed it will be possible for the study to contribute input to the planning and design of the Trinity River Project. Response to this input, in the form of modified designs, can be recycled through the models, in order to verify design validity. It is hoped that this feedback mechanism would continue to operate for the life of the Trinity River Project.

The environmental study will identify many local problems worthy of more detailed study. Those responsible for basin management should investigate these problems as time and money become available.

## FOURTH STAGE
## PREPARATION OF ENVIRONMENTAL STATEMENT; DEVELOPMENT OF SURVEILLANCE MECHANISM

Upon completion of Stage Three the research necessary for preparation of an environmental statement will be completed. The avenues of investigation suggested by NEPA will have been explored. The formal statement, to be submitted to the Council on Environmental Quality, should be prepared by SCAT and the Fort Worth District Corps of Engineers, using the material obtained in the study program.

At this time a formal mechanism should be established to permit continued surveillance of environmental conditions within the basin. Details on the surveillance should be presented in the impact statement. A possible framework would be to utilize the members of SCAT as consultants on environmental matters within the Trinity Basin. Their surveillance of the basin would include updating of ERU and other mapping, expansion of matrix data as environmental conditions within the basin change or become better known, and use of the computer model to aid in basin management decisions and project designs.

Much research will remain to be done, even after completion of this landmark study. Further investigations of problem areas should be encouraged, in order to approach a complete understanding of the Trinity River Basin. The surveillance mechanism should serve to guide this future research so that the results will be of direct value to wise management of resources within the basin. Thus the entire study will serve as the framework for continued enlightened environmental planning within the watershed of the Trinity River.

APPENDIX A:
GENERAL INFORMATION ON THE STUDY PLAN

In this appendix are given: a list of acronyms used in the text and appendices of this report; a simplified chart or organization for the study; and a summary of scheduled activities planned during the study. A more detailed organization chart appears in Appendix F; the same appendix contains detailed charts showing the scheduled activities and landmarks during the study.

## Part I: Acronyms

BEEF - Basin Environments Evaluation Force

The task force of specialist scientists who are to make detailed studies of environmental conditions within the Trinity Basin, and who will evaluate the effect of the Trinity Project on hydrologic, ecologic, and socio-economic factors within the watershed.

ERU -- Environment Resource Units

Natural units in the environment, defined by observing patterns of landforms, soils, water conditions, and biota. A landscape component containing an easily described complex of environmental conditions is an ERU. See Appendix K for description of "Land Systems", which are similar to ERUs.

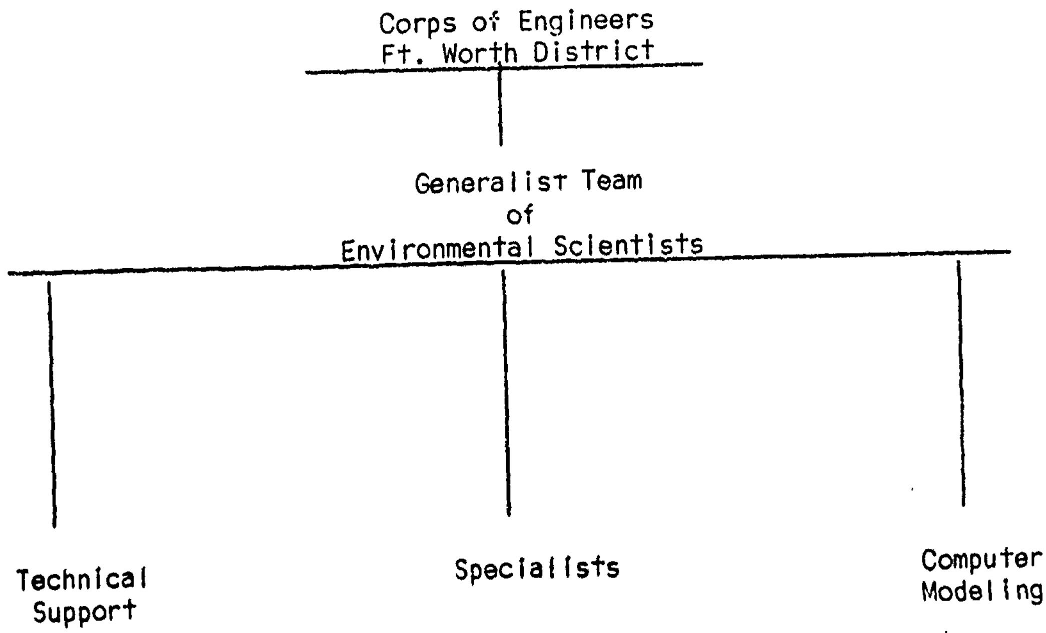
NEPA - National Environmental Policy Act

Public Law 91-190, containing specifications for the performance of environmental research where the public interest is involved.

SCAT - Systems Coordinating & Analysis Team

A select group of envrionmental scientists whose broad training will enable them to conduct interdisciplinary surveys of natural resources and human activities within the Trinity Basin. This team is responsible for mapping ERUs, supervising all professional work done as part of the study (e.g. by BEEF), and for performing the synthesis of qualitative and quantitative information which will lead to preparation of the environmental statement required by NEPA.

## Part 2:
## Simplified Chart of Organization



Part 3: Activities during Implementation of Study Plan

| | |
|---|---|
| Stage One: Acquisition of Basic Environmental Information (3 - 4 months) | Literature and data search<br>Matrix for data storage<br>Computer modeling<br>Environmental resource mapping |
| Stage Two: Acquisition of Detailed Environmental Information (8 - 14 months) | Instrumentation for new data<br>Data analysis by specialists<br>Study of project alternatives<br>(Computer modeling, continued) |
| Stage Three: Synthesis and modeling (4 - 6 months) | Qualitative synthesis<br>Quantitative modeling<br>Design input |
| Stage Four: Preparation of statement and surveillance mechanism (2 - 3 months) | Environmental statement<br>Continued surveillance<br>Continued study<br>Continued planning |

Total: 23 - 25 months

## APPENDIX B:
## PERSONNEL AND SUPPORT PERSONNEL FOR SCAT (SYSTEMS COORDINATING AND ANALYSIS TEAM)

### Part 1: SCAT

The selection of broadly trained scientists for the Systems Coordinating and Analysis Team (SCAT) represents one of the most important aspects in preparation for the environmental study. Each team member should have a Ph.D. or equivalent degree, with experience in making meaningful field studies. Each should be capable of supervising a large staff, and most importantly, needs to be fully aware of the many intricacies of the environmental sciences.

Each member of SCAT should be retained for a period of 24 months, with arrangements for consulting thereafter. Each scientist should work full-time on the study, and must not have any duties outside the scope of the study. It will be advisable to contract the research to a non-academic, non-government organization which is capable of providing administrative support and technical advice to the team of scientists. The scientists can be associated with this organization, provided they have no obligations except to fulfill the objectives of the study plan.

Maximum flexibility will be obtained if SCAT is independent of the fixed structure of a government agency, and independent of the academic orientation of educational institutions. The team could be a semi-autonomous body within the associated organization, with direct communication to the Corps. The associated organization would enhance these lines of communication, provide administrative services, and act as consultants for the study.

The scientists should be chosen so that their combined expertise matches the categories of research undertaken. A combination of disciplines which has had success elsewhere is as follows:

1. Ecologist (usually the team leader) - familiar with terrestrial and aquatic ecology, able to deal with factors of human stresses on ecosystems, conversant with all fields of the natural and social sciences.
2. Hydrogeologist - familiar with engineering geology, hydrology, and geomorphology, able to analyze the natural dynamics of the land surface as they relate to biology and human activities, and conversant with virtually all fields of the natural (and some social) sciences.
3. Soils agronomist - familiar with soil science, including soil chemistry and hydrology, able to assess land use patterns in rural areas, and conversant with the natural and social sciences.
4. Social scientist - familiar with economics, politics, sociology, and other social sciences, able to evaluate land use trends and regional planning, and aware of the role of natural factors in influencing human activity.

In support of SCAT personnel additional staff are required, as listed in subsequent sections of this appendix. The support personnel, who might be part of the associated institution, are expected to provide services for all aspects of the study project, including the specialist studies listed in Appendix D. Some of the specialist studies will impose short-term work loads requiring additional personnel, as listed in Appendix E.

## Part 2: Office staff

SCAT should be supplied with the equivalent of two full-time assistants for purposes of secretarial duties. These assistants will be required for the entire two-year period of the study, and should have no obligations except to the environmental research program. Additional office staff (typists) will be required for preparation of final reports.

## Part 3: Research staff

The basic environmental research for the study will require considerable library research, including data collection. During the initial stages of the study, e.g. for six months, the research staff should consist of four persons. At least one of these should have a degree (masters) in library science, and can lead the team, while the others should have at least a B.S. The research team should include specialists in environmental literature, scientific literature, and maps and data. The final member should be experienced in researching problems of regional planning and project designs. During subsequent stages of the study, e.g. for the next twelve months, the research staff should consist of at least two persons.

## Part 4: Laboratory staff

Laboratory work will be required for analysis of soil, water, and biologic samples obtained during field investigations, including investigations by the specialist scientists. Major work requiring considerable equipment should be sub-contracted to existing laboratories, or done through government agencies which cooperate with the project.

However considerable savings in time and funds will be brought about by the development of small basic laboratories associated with the generalist work. Equipment requirements for the laboratory are indicated in Appendix G. The great volume of data analysis required for a study of a basin as large as the Trinity will require a laboratory staff of four persons. Three of these will be advanced technicians (B.S., or M.S. level), capable of handling soils, water chemistry, and bioassays respectively. The best qualified of these persons should supervise all laboratory work. The fourth person should be a technician to perform the more routine tasks of the laboratory work. The laboratory staff will be required for about eighteen months of the study.

## Part 5: Field staff

During the period of field work by SCAT (about two months) two technical assistants should be available to assist with sampling programs and equipment manipulation. One assistant should have a B.S. in some aspect of field science (e.g. soils or biology), while the other can have no formal training in science. These assistants should be retained for an additional six months so that they may be seconded to specialist members of BEEF, as required.

## Part 6: Cartographic staff

During the study there will be many mapping projects, which will require at least two full-time professional cartographers with the responsibility of preparing ERU and land-use maps for the specialist research. During the closing phases of the study and especially for preparation of the environmental statement, this staff should be expanded to include three full time cartographers/draftsmen. If drafting staff is available from the Corps or other sources, this staffing requirement may be altered.

All work regarding remote-sensing imagry should be subcontracted, so that no additional personnel are needed for duties associated with the imagry.

## Part 7: Computer staff

The extensive computer staff outlined in Appendix H should budget time for undertaking statistical studies and small modeling projects required by the generalists. The half-time services of one statistician-programmer can be allotted for SCAT.

## Part 8: Administrative staff

The associated non-academic institution should provide all administrative staff required for all phases of the proposed study. One person should be detailed full time to supervise the administration of the study, with the assistance of personnel (e.g. accounting staff) nominally part of the associated institution.

## Part 9: Logistical support

SCAT will require logistical support in addition to provision of the staff itemized above. This support is outlined in Appendix G (non-computer) and Appendix H (computer).

This support includes the provision of office space, remote sensing imagry, and field sampling equipment. In addition the team must be supported during a one and one-half month period of field work. Transport during the field work must be provided, and will include a four-wheeled vehicle, boat, and during short periods. a helicopter.

## APPENDIX C:
## GENERAL REQUIREMENTS FOR BEEF

SCAT has the duty to initiate environmental research proposed in this study plan, and to synthesize material resulting from the research. However much of the actual data acquired during this study will result from the work of the Basin Environments Evaluation Force (BEEF), who will act under the direction of SCAT.

Information on the specialist studies appears in several appendices. In this appendix are given the general characteristics of the studies, while in Appendix D there appear itemized details concerning the explicit requirements of each study. In Appendix E are indicated personnel requirements for BEEF as a whole, and a general framework for organization of the research.

## Part I: Approach of BEEF

At this stage it is not possible to indicate all details concerning BEEF. To maintain flexibility it is desirable that only a broad spectrum of suggested work be outlined at this time, sufficient to facilitate selection of appropriate personnel, and to acquaint each specialist with the approximate scope of the anticipated research.

After completion of stage one of the study SCAT should review the proposed specialist research. Where possible leaders of on-going research projects within the basin should be asked to cooperate fully with the environmental study project. Such cooperation may permit transfer of some of the work of the specialist disciplines listed in this report.

Additionally the research programs of government agencies may offer potential assistance to the study. Where such programs can be adjusted to provide input of the type required for an environmental statement the appropriate agencies should be so informed, and cooperation should be arranged.

Given the inputs from existing research programs and given the basin environmental information acquired by SCAT, the BEEF studies can be planned in detail and executed. The revised research may be more extensive, less extensive, or merely of different emphasis than that itemized in Appendix D.

The information given in these appendices is thus a best effort of research needs, assuming that all work will be done within the framework.

outlined in this report, and not by independent academic institutions or government agencies. It is recognized that there may be considerable changes in this framework, and that the estimates of personnel, equipment, and cost will need to be revised after the initial stages of the overall study are completed.

It is further recognized that many of the specialist studies will uncover environmental problems within the Trinity Basin, and that additional research will be needed to clarify and solve these problems. Such research is beyond the scope of the two-year study planned here. This study has the limited goal of identification of environmental impacts resulting from the Trinity River Project or other developments.

## Part 2: Basic objectives of BEEF

A. Inventory known information about the subject matter of the specialist study, as provided by literature search part of the overall study, and as otherwise available. Study the ERU mapping, and overall characteristics of the basin. Establish liason with other specialists who may provide information of value. Prepare and implement a sampling program to provide additional information, where available data are inadequate.

B. Engage in necessary field work to obtain more complete information about the characteristics of the Trinity River Basin.

C. Process all information obtained, using appropriate laboratory techniques and mathematical treatments. Interpret information in terms of the Environmental Resource Units. In particular, comment upon the suitability of the mapping of these units, and provide precise characterizations of each unit and sub-unit.

Organize information for input to computer modeling studies. In particular comment about the suitability of the model structure, and nature of output as related to the subject of the specialist study.

D. Review conclusions of other specialist studies and review the results of the study of project alternatives. Comment upon relationships between project development, project alternatives, and the Trinity River environment, as shown in specialist study. Evaluate proposed land use within the basin as a result of various alternatives, and comment on those land uses which seem most appropriate and least appropriate.

E. Prepare final report of specialist study, for inclusion as appendix to environmental statement.

F. Consult with team planning continued surveillance and monitoring of environmental conditions within basin.

# APPENDIX D:
# ORIENTATION AND ORGANIZATION OF BEEF

This appendix contains 32 parts, each part giving the detailed characteristics associated with one of the specialist studies outlined in the study plan. For each of the 32 task forces the following information is presented:

1. Goals of the study - data, concepts, and interpretations needed.
2. Activities required for the study.
3. Environmental interrelationships of particular importance, including:
   a) committee membership (see Appendix E).
   b) other studies providing input to the specialist research
   c) other studies receiving output from the specialist research
4. Categories of information to be input to SCAT, especially ERUs.
5. Data inputs for computer modeling; special computer requirements.
6. Man-hours of work required for the study, broken down into:
   a) man-hours of professional work (Ph.D., or P.E.)
   b) man-hours of technical work (lab or field assistants)
7. Personnel requirements for BEEF, including levels of education and experience.

8. Approximate scheduling of the study, broken down as follows:

(For exact schedule, see Appendix F)

a - Data review, development of monitoring

b - field work (if any)

c - analysis of data

d - input to ERU mapping and computer modeling

e - evaluation of project impacts

f - preparation of final report

9. Special equipment needed for the study.

10. Special technical support required for the study.

11. Monitoring required after study is completed.

12. Additional comments.

## PART I: GENERAL GEOLOGY

1. Geological information is needed for the entire Trinity River Basin, especially in areas of proposed construction or inundation. This study will provide a baseline of information on:

   a) distribution of surface sediments and rocks (i.e. mapping of materials and not the mapping of strata, as identified by fossil assemblages)

   b) distribution of potential resources, such as fossil fuels, construction materials, and areas suitable for solid waste disposal

2. The main activities will be:

   a) interpretation of existi.. geological maps, from the point of view given in 1., above

   b) photo-mapping (reconnaissance) in areas where information is lacking

   c) field check of problem areas

   d) interpretation, input to other studies, report preparation

3. The general geology study will be part of a baseline study providing input to many other studies of the physical environment.

   a) member of Committee on Hydrophysical Environment

   b) input from studies on the physical geography of the basin (e.g. engineering geology, geomorphology, pedology)

   c) output to studies as above, plus analyses of basin hydrology (e.g. groundwater, water quality)

4. For each ERU the typical bedrock and surface materials should be characterized. Mapping should emphasize units which determine physical conditions at the surface.

5. The computer model will utilize codes for indicating the geology at each grid point, and indices (e.g. runoff coefficients) may be determined for each unit.

6. a) 1000 man-hours (professional) are needed

   b) no special technical work is needed

7. One geologist is needed, with experience in interpretation of surface materials.

8. a) 1½ months

   b) 1½ months (mostly office analysis of imagry)

   c) 1½ month

   d) 1 month

   e) none

   f) ½ month

9. Some special equipment is needed for this study, including a mirror stereoscope (one month) and minor field gear.

10. Technical support required includes a copy of remote sensing imagry, and transport to field areas.

11. No monitoring is needed after the study is completed. However areas of project activity should be studied in detail, as required.

12. Resources identified by geological mapping should not be permitted to be misused by any proposed basin development. Limitation on development should be clearly specified.

## PART 2: ENGINEERING GEOLOGY

1. The study of engineering geology will aim to determine the engineer-characteristics of surface and near-surface materials at sites slated for construction or major development within the basin. In particular the geology at proposed dam and channel sites must be determined at least on a reconnaissance basis.

2. The first activity of the engineering geologist will be to review existing information on bedrock geology, surface geology, and engineering geology within the basin. Field activities will follow, and have two components:

   a) reconnaisance of construction sites, and collection of on-site data and samples (including bores) for laboratory study

   b) sampling of engineering geology characteristics for each ERU and major sub-unit not already described in literature. A variety of measures of the geology must be determined, e.g. soil mechanics parameters (including strength), fracture density, natural drainage, and other factors affecting the physical character of the land surface

3. The engineering geology study will be a baseline study with important input to project design.

   a) member of committee on Hydrophysical Environment; member of committee on Project Design and Basin Management

   b) input from studies on general geology, pedology

c) output to hydrological studies, and research on project designs (e.g. construction, basin management)

4. This study should provide detailed quantitative information on the engineering site characteristics of typical components in each ERU. A major part of the ERU description will consist of tables giving these characteristics.

5. Generalization of the data will provide quantitative input on surface geology for both the basin data grid, and the floodplain data grid. Actual field sampling should be designed to provide representative data for all important areas of the basin.

6. a) 2,000 man-hours

   b) 1,000 man-hours

7. A professional engineering geologist, preferably oriented toward construction sites, will be needed to work full time throughout the life of the study. A technician (B.S. level) will be needed as a laboratory, field, and office assistant.

8. During parts of the study it will be necessary to put into the field a full soil-testing equipment package, including machinery for making bores. Access to a testing laboratory is also required. If equipment is not available from within the corps, this work may be subcontracted.

9. Technical support consists mainly of the field equipment and testing laboratory specified above. Access to some field sites may require a four-wheel drive vehicle. Air-photos of possible dam sites should

be available.

10. The technician is needed for phases b and c only.

    a) 2 months

    b) 4 months

    c) 2 months

    d) 2 months

    e) 1 month

    f) 1 month

11. No additional monitoring is required after the study. However, the study must be regarded as a reconnaissance, so that detailed engineering studies must proceed any actual construction.

12. It should be stressed that the studies of the engineering geologist are to be oriented toward determining land characteristics that influence potential land use. It is vital to identify sites and ERUs that have engineering problems which will inhibit intensive development, so that project planning can be adjusted accordingly.

## PART 3: GEOMORPHOLOGY

1. Specific information is needed on the full suite of fluvial geomorphic processes active within the Trinity Basin.

   a) it is necessary to analyze floodplain processes during periods of high-flow: siltation, bank caving, scour and fill

   b) It is also vital to study slope processes related to production of runoff and sediment

   c) Also needed is information on the morphometry of the basin

   d) Finally data is required on the character and intensity of surface processes active within each ERU

2. a) For floodplain studies it is necessary to analyze sequential air-photos and maps to determine all morphological changes produced by fluvial dynamics throughout the length of the main river

   b) Selected floodplain areas will be chosen for field analysis, in which bore holes will permit a stratigraphic reconstruction of floodplain history

   c) A key result of this activity will be the determination of the effect of various human activities on floodplain processes and rates of change, as reflected in changes in sediment type, due to natural changes within the basin

   d) The study of geomorphology will also require the designation of important reaches of the river for surveying before and after each high water season, for the duration of the project

e) Field measurements of processes along channels will be necessary during flood seasons that occur during the study period. Reaches below urban areas are of special interest

f) A minor activity of the geomorphology study will be to confirm the basic geometrical properties of the drainage net within the basin, and to analyze various morphometric indices for input to computer modeling

g) The geomorphology study will analyze available USDA equations for soil loss on watershed slopes throughout the basin. The validity of these equations will be tested by comparison with actual sediment data, and by field examination

h) For areas with poor data, additional field sampling may be required

i) Other processes (e.g. weathering, mass movement) will be evaluated on a reconnaissance basis, so that the overall dynamic balance of forces acting on slopes can be estimated. The process-evaluation will be organized by ERUs and sub-units

3. The study of geomorphology is closely tied to all research on basin hydrology and aquatic characteristics.

a) member of the committee on Hydrophysical Environment; member of the committee on Biol[illegible]

Land Use

b) Input will come mainly from research on basin geology, climatology, pedology, water balance hydrology, river hydrology and stream dynamics

c) Output will be directed toward research on river hydrology, stream dynamics, limnology, aquatic ecosystems, water quality, and all studies concerned with design on or management of floodplains

4. The geomorphology study will supply the generalist mapping team with quantitative evaluations of processes active in each ERU and sub-unit, and will comment on unit-boundaries where these are not the same as natural boundaries.

5. All products of the study will be input to the computer modeling.

a) Initially the morphometry of the basin needs to be analyzed, prior to digitization.

b) Then quantitative data on floodplain and slope processes need to be established.

c) The effects of processes on floodplain conditions need to be quantified, insofar as possible

d) The simulation of land use changes within the basin, using the computer models, should show expected results in floodplain morphology, erosion, and sedimentation. Of special importance is the simulation of proposed conservation measures which will affect sediment delivery to the major streams, and the evaluation of project goals as a function of the success of these measures. The validity of the simulations should be analyzed in terms of known geomorphic phenomena within the basin

6. a) 3000 man-hours

   b) 2000 man-hours

7. The study requires two Ph.D. geomorphologists, and one with an M.S. One Ph.D., specializing in floodplain analyses, will work full time during the year of specialist studies, and will utilize the full-time assistance of an M.S. technician. A second Ph.D. should work 6 months to analyze slope processes.

8. The geomorphology study will require the availability of field surveying equipment, boring equipment, and the capability for photogrammetric analysis of imagry. One set of all basin topographic maps will be supplied for this study.

9. Technical support for considerable field work needs to be supplied to this study, including vehicles for access to floodplain areas during wet periods.

10. The study of floodplains should proceed thusly:

    a) 1 month

    b) 4 months, plus additional 2 months as needs warrant

    c) 1 month

    d) 2 months

    e) 1 month

    f) 1 month

11. After the study is completed, it is anticipated that monitoring of floodplain processes will continue, including repetitive photographic analysis, and surveying of major reaches. Limited monitoring of slope processes is also suggested, for areas of prime interest (e.g. major sediment producing areas). The study of slopes should begin in time to permit analysis of slope processes during a storm season, and should proceed thusly:

a) 1 month

b) 2 months

c) 1 month

d) 1 month

e) ½ month

f) ½ month

12. The role of the geomorphology study is very critical to the environmental study, since the major physical changes in landscape quality caused by the project will reflect physical changes in geomorphic conditions within the basin. The basic goals of the geomorphology study are thus two-fold. First, to evaluate the process-dynamics within the basin, and to indicate relationships between these dynamics and other environmental conditions within the basin. Secondly, to establish existing relationships between human activity and landscape change within the basin, as a guide to interpreting consequences of further basin development.

PART 4: WATER-BALANCE HYDROLOGY (INCLUDING RUNOFF)

1. Baseline information required from this study is an analysis of all data which determines overland and underground water movements to major streams, lakes, and reservoirs within the Trinity Basin. The study will consist mainly of an analysis of existing hydrologic data and water-balance formulas.

2. The main activity during the study will be

   a) The compilation of hydrologic data

   b) evaluation of relationships between land conditions and resulting runoff, groundwater storage, and evapotranspiration

   c) where data is inadequate it will be necessary to establish field sampling stations to supplement the available information

   d) evaluation of computer models on basin hydrology

3. a) member of the committee on Hydrophysical Environment; member of the committee on Biological Environment and Land Use

   b) This study will require considerable input from research studies which are determining surface conditions within the basin: climate, geology, geomorphology, soils, ecology

   c) The study will provide information of value to the above (b), especially by supplying information on water-balance for each major ecosystem and water supply to major streams

4. The water-balance study will provide quantitative characterization of the fate of water which enters each ERU and sub-unit.

5. The water-balance study will aid in the computer-analysis of hydrologic data, particularly runoff and evapo-transpiration. Models dependent on this information will be those in which runoff is predicted as a function of stream characteristics, soil condition, topography, and ground cover, and those in which evapo-transpiration is predicted. The effect of the project on water-balance hydrology can be estimated with considerable precision if the models are correctly formulated.

6. a) 2,000 man-hours

   b) none

7. One hydrologist (Ph.D.) is required full-time for the duration of the study.

8. It may be necessary to equip several small gauging stations to provide data for this project, and to install additional monitoring devices, such as evaporation pans, lysimeters, and storm-rainfall gauges.

9. Technical support includes supply and data collection associated with field stations, magnetic tapes with existing gauging station data, and considerable computer time.

10. The study will continue through the duration of the specialist work, with a breakdown as follows:

   a) 3 months

b) 1 month

c) 2 months

d) 4 months

e) 1 month

f) 1 month

11. It is anticipated that the water-balance study will indicate areas in which monitoring of surface runoff is inadequate; monitoring in such areas should continue after the study is completed.

12. It should be emphasized that the water-balance study is used in characterizing ERUs, and of particular importance in the formulation of computer models for simulating basin hydrology. The environments influencing water movement to streams are the same environments which will be modified by development associated with the project. The sources of main flow components in the project area can be resolved only if the upland hydrology is well understood.

## PART 5: RIVER HYDROLOGY

1. The study of river hydrology should produce

   a) baseline information on water flows in the Trinity River and major tributaries, as a function of environmental conditions within the basin

   b) seasonal analysis of hydrodynamic regimes within the basin as a function of climate, land use, and physical characteristics of the landscape

   c) flood hydrographs for different storm magnitudes and locations and the probabilistic aspects of floods and droughts

   d) evaluation of the effect of project structures, other structures, and flood control programs, as they effect river hydrology

   o) recurrence intervals of long periods of low flow

2. a) the initial activity will be to make a compendium of data on river hydrology within the basin, and to institute an extensive sampling program to augment this data

   b) interpretation will be limited mainly to data on hand, as the new sampling programs will require several years before usable information is available

   c) technical collection of data will continue, and the study should involve considerable mathematical treatment of the observed data, covering all aspects of traditional hydrologic methodology

d) a major activity will be the checking of computer models so that the effects of flood control (and other) structures on river hydrology can be simulated and evaluated

3. a) member of the committee on Hydrophysical Environment; member of the committee on Biological Environment and Land Use; member of the committee on Project Design and Basin Management

b) the river hydrology study will obtain much information from the study of water-balance hydrology, and will require information from all studies of tributary environments: geology, soils, ecology, climate, etc.

c) river hydrology input will be of particular importance to the study of aquatic ecology, floodplain geomorphology, the social-economic aspects of basin planning, and engineering of the project (e.g. dredging needs)

4. The river hydrology study will provide input to those ERU's which include major stream components, but is not otherwise important to the ERU mapping. In contrast, the river hydrology is a function of ERU characteristics, and a correlation of the hydrology with those characteristics will be a good test of the validity of the ERU concept.

5. All aspects of computer modeling of river flows are dependent on this study for specific input data. All data obtained from the study must

be in a format suitable for computer use. As indicated above, many of the important models are those designed to predict river hydrology, and thus this study must be designed to evaluate and improve those models.

6. a) 4,000 man-hours

   b) 4,000 man-hours

7. The professional staff must be two experienced surface water hydrologists, familiar with hydrologic regimes in rivers like the Trinity. The two members of the technical staff will be used to supplement existing gauging station personnel.

8. Full gauging station equipment will be required for this study - the exact number of stations will be determined at the beginning of the study.

9. Technical support of the gauging stations will be required, including vehicle access to stations during wet periods. Access to small computers is an essential part of the study, due to the extensive mathematical manipulation of data that will be required; data already on magnetic tape should be obtained.

10. Acquisition of data and evaluation of same will proceed throughout the study with breakdown of specific activities as follows:

    a & b) 1 month (technicians continue for 10 months)

    c & d) 9 months

    e) 1 month

    f) 1 month

11. This specialist study will require the establishment of several new

gauging stations, and the continued monitoring of the stations after the study is completed; monitoring can be done by existing government agencies

12. Evaluation of river hydrology is perhaps the part of the environmental study that is most directly related to evaluation of the Trinity River Project. The feasibility of the project is primarily a function of its effect on and compatability with the existing hydrologic regime of the basin. The effect of past land use practices on changes in the regime must be documented, in order to successfully evaluate the probable nature of future changes. Proper formulation of the computer model is essential here, since continued simulation of basin changes should continue long after the basic environmental study is complete.

## PART 6: STREAM DYNAMICS

1. The purpose of the stream dynamics study is to investigate the dynamics sediment transport within the Trinity and all important tributaries, in order to analyze the effect of further river regulation upon the transport. Specific information needed includes:

   a) an extensive evaluation of existing sediment discharge data, and sampling to provide additional data

   b) Analysis of the data in terms of fluvial mechanics in the transporting fluid

   c) Coordination with studies of geomorphology, water-balance hydrology, and river hydrology, in order to evaluate the environmental characteristics which in many cases are more important than fluvial mechanics in determining sediment supply and movement

2. a) The initial activity is to identify areas where additional sediment data is required, and to implement data collection. As with all other monitoring done in this study, the distribution of sampling stations can be determined by checking the distribution of distinct ERU and sub-units against the distribution of existing stations, and locating new samples in units (or in tributaries draining units) which are not now well covered

   b) Analysis of the data, including statistical treatment in which variations of sediment yield are correlated with all environmental parameters which affect material supply and transport.

c) Calculation of the effect of project components on sediment movement through the system, including areas of probable siltation, (channel, reservoir, floodplain) and erosion (bank and bed)

3. a) Member of committee on Hydrophysical Environment; member of committee on Project Design and Basin Management

   b) Input should come from all studies determining the supply of sediment and water to the channels, namely studies of geology, geomorphology, hydrology, land use, and project design

4. Input to ERU mapping is minimal from this study, except to confirm aspects of sediment supply determined in geomorphology study. However unit mapping of floodplain areas can be checked against results of this study, and transport capacity of each reach should be specified.

5. All data from this study will be input to computer modeling. A prime task of the study will be to evaluate those models which sediment transport in areas studied, with particular thought to environmental factors in tributary basins which are responsible for sediment supply.

6. a) 2000 man-months

   b) 4000 man-months

7. The study requires one full-time professional scientist,

preferably a Ph.D. or M.S. geologist with a strong engineering background, since many of the sediment supply problems are geological, and not a function of fluvial dynamics. Two technicians are needed to visit the sediment sampling stations.

8. Sediment sampling equipment and a sediment laboratory are needed for this work. Vehicles for access to field stations will be required.

9. Technical support includes the sediment laboratory, and additional technicians for sampling during flood periods. The soils laboratory established for SCAT can perform the needed sediment analyses.

10. a & b) 1 month, plus continued sampling by technicians

    c) 6 months

    d) 2 months

    e) 2 months

    f) 1 month

11. This study will establish monitoring stations for sampling sediment discharges; such monitoring should continue as long as sediment information is needed for planning within the Trinity Basin.

12. It should be stressed that the study of stream dynamics is essential to all aspects of the Trinity River Project which envisage any modification of channel characteristics, or any basin changes affecting channel sediment supply and transport.

In particular, estimation of dredging needs, reservoir siltation, and bank changes are all dependent on this study.

## PART 7: GROUNDWATER HYDROLOGY

1. The baseline information needed concerns the identification of important aquifers, recharge areas, and discharge areas within the basin, and the rates and directions of groundwater flows. The information on groundwater will be used to complete knowledge about the hydrologic cycle within the basin.

2. a) The major activity will be to review published information on groundwater conditions within the basin

   b) Limited field work (pumping and tracing tests) might be needed for areas where little information is available, or where major disruptions of the hydrologic system are anticipated (e.g. proposed reservoir sites)

   c) Evaluation of long-term supply and quality of groundwater

3. a) member of committee on Hydrophysical Environment

   b) The study will require input from geological, climatological, and hydrological studies

   c) The study will provide input to work on water balance, river, hydrology, and water supply

4. The groundwater conditions of each EPU should be characterized as a result of this study.

5. Groundwater parameters affecting surface hydrology, or determining major inter-basin flows, should be part of computer models.

6. a) 1000 man-hours

   b) none

7. One professional hydro-geologist (Ph.D. or M.S.) is needed for the study.

8. No special equipment will be required, unless field tests are needed, in which case contracts should be let for temporary use of drilling and pumping devices.

9. No special technical support is required for this project, except access to computer time for digitizing and storage of water data.

10. The study should proceed as follows:

    a) 2 months

    b) ½ month

    c) 1½ months

    d) ½ month

    e) 1 month

    f) ½ month

11. Tests of groundwater flow may be required for local areas, in general no basin-wide monitoring of groundwater is contemplated, over and above continued surveillance of well levels in areas where groundwater is utilized for water supply.

12. Attention should be paid to any project components which will affect groundwater levels or flows, and any related development which might cause groundwater levels to seriously decline, and limit water supply.

## PART 8: WATER QUALITY

1. The water quality study will provide data on:

   a) quality and quantity of all point discharges

   b) quality and quantity of all point diversions

   c) character of discharges in all reaches

   d) water quality in all tributary basins

   e) sources of materials flowing through system

   f) rate processes of pollution indicator parameters (BOD removal, aeration, etc.)

   In addition the study should:

   g) design a valid water quality surveillance program

   h) design a program for water quality management

2. The study will consume considerable man-hours of work, because of the extensive field sampling required.

   Specific activities are:

   a) review existing data and sampling programs

   b) design system for inventory of discharges, diversions

   c) design system for field sampling of water characteristics

   d) analyze water treatment capabilities in basin

   e) provide close cooperation between data gathering technicians and computer digitizing staff

   f) help formulate computer models for predicting and managing water quality

   g) devise continuous surveillance system for use after study is completed, and prepare alternative management plans with built-in options

3. a) members of this study are on all of the BEEF committees

   b) input will be needed from climatology, hydrology, aquatic ecosystems, agriculture, forestry, and regional planning

   c) output will be most directly aimed at aquatic ecosystems, limnology, and basin management studies

4. SCAT will depend on the Water Quality group for information regarding:

   a) sources of water-borne materials

   b) distribution and kinetics of pollution control (P.C. parameters)

   c) discharge/diversion data

5. Data inputs by the Water Quality group for computer modeling should permit:

   a) quantification of kinetics of natural stream water quality renovation

   b) quantification of downstream movement and dispersion of materials

   c) documentation of seasonality of P.C. parameters

   d) discharge/diversion inventory

6. lan-hours of work:

   a) 6,000 hours

   b) 8,000 hours

7. Personnel requirements:

a) project coordinator (graduate degree and experience)... 1 man

b) biologist-chemist (degree and familiarity with water quality surveillance programs)...2 men

c) technical (field, laboratory)..4 men

8. Scheduling:

a) 1 month

b) continuous by technicians

c & d) 12 months

e) 1 month

f) 1 month

9. Special equipment needs include transportation for field sampling gear; two boats and outboard motors; sampling equipment for water; sediment, benthos; and basic P.C. field instrumentation.

10. Special technical support needs include water and sediment analysis capability for at least the following parameters:

a) dissolved oxygen

b) biological oxygen demand

c) total, particulate and dissolved carbon

d) sulfates

e) chlorides

f) plankton pigment concentrations

g) dissolved solids - conductivity

h) suspended solids

i) coliform counts

j) nitrogen series

k) phosphorus series

l) metals

m) alkalinity

n) pH

o) hardness

11. A continuous surveillance and reporting system for all pollution control and other parameters will be necessary for implementation of water quality management, and should continue for the duration of all management of the Trinity Basin.

12. Maintenance of water quality to meet existing stream standards is a crucial factor in implementation of the Trinity River Project.

## PART 9: CLIMATOLOGY

1. A full analysis of climatic and meteorologic conditions is required, for each ERU and for each major tributary, in order to determine conditions which effect basin hydrology and ecosystem structure. The bulk of this information is published, and needs to be reworked for proper integration into the environmental study.

2. a) The primary activity of the specialist study will be to review existing climatic data and to provide analyses about the probabilistic aspects of storm events

   b) Where data are lacking, new monitoring stations should be established, but information from the stations will not be useful until several years after the study is completed. This information should prove valuable in detailed project planning

   c) Modeling of storm patterns should be utilized for prediction of hydrologic events

3. a) member of committee on Hydrophysical Environment; member of committee on Biological Environment and land use; member of committee on Project Design and Basin Management

   b) No direct input from other studies, except specifications regarding types of data required (e.g. for water balance study)

c) Input will be directed toward studies of hydrology, water supply, air quality, limnology, agriculture, forestry, aquatic and terrestrial ecosystems, wildlife management, project design and basin management, and others

4. The climate conditions typical of each ERU should be specified quantitatively, as a result of this study.

5. All climatic data will be used as input to computer modeling. Special modeling of storm patterns will be needed.

6. a) 1500 man-months

   b) none

7. One Ph.D. level climatologist experienced in computer modeling should be used.

8. Climate station equipment will be necessary should new stations be required, but no other special equipment is needed.

9. Technical support required includes access to computer time for the purpose of modeling and analyzing climatic events and statistics. Magnetic tapes with climate data should be obtained.

10. The study can be scheduled as follows:

    a) 1 month

    b) none

    c) 3 months

    d) 4 months

e) ½ month

f) ½ month

11. Monitoring established by this study, e.g., climate stations in key areas or in areas where data are lacking, will be used after the study is completed.

12. A topic of special interest is the microclimatic effects of reservoir construction, urbanization, and other developments associated with the project and other alternatives. This topic should be covered if time permits.

## PART 10: AIR QUALITY

1. It is important for the study of air quality in the Trinitv Basin to determine:

    a) air quality conditions in the basin today

    b) identify sources of pollution, including gasses, vapours, metals, and particulates

    c) probable changes in air quality resulting from the Trinity River Project (e.g. due to barge traffic, industrialization)

    d) possible management programs to insure high quality air throughout the basin

2. The primary activity during this study will be the analysis of data, as collected by air control authorities, and as collected in this study by sampling around pollution sources. The secondary activity will be the evaluation of project effects and possible management programs

3. a) member of committee on Socio-Economic Environment; member of committee on Project Design and Basin Management

    b) input from climatology, land use studies, and regional planning

    c) input will be provided mainly to long-term planning and basin management

4. Ambient air quality found over each ERU should be determined.

5. The main computer model of the basin will not include air quality data, but such data will be separately modeled for urban areas.

6. a) 1,500 man-hours

   b) 3,000 man-hours

7. One professional, with a M.S. or advanced engineering degree is required, with three technicians (B.E.) to work six months each.

8. Complete air sampling equipment will be required for this study, including sampling trains, high-volume samplers, and wind gauges.

9. Vehicles for field sampling are needed. Access to SCAT chemistry lab should be provided, for sample analyses.

10. a) 1 month

    b) 1 (six months by technicians)

    c) 3 months

    d) 1-1/2 months

    e) 1-1/2 months

    f) 1 month

11. The air monitoring program should be continued after the study is completed.

12. This study will ascertain the degree to which air quality conditions have already deteriorated within the basin, so that the effects of the project can be clearly determined.

## PART 11: LIMNOLOGY AND OCEANOGRAPHY

1. The team of limnology and oceanography specialists will report on:

   a) Hydrographic conditions in reservoirs, waterways and estuarine areas in the basin (e.g., thermal properties, circulation patterns)

   b) Anticipated hydrographic conditions behind barrages and along canal lengths to be constructed

   c) Estimated effect on water quality

   d) Levels of thermal loading and other pollution

2. The team will conduct field research on reservoir hydrography and circulation, and waterway transport phenomena. The following activities will be performed:

   a) Profile water masses in reservoirs

   b) Determine circulation patterns in estuarine areas

   c) Map proposed reservoir profiles and project expected circulation patterns and water quality

   d) Anticipate hydrography of lock and canal areas

3. Interrelationships of particular interest are those of reservoir hydrography and water use, ecology, water quality, and weather:

   a) Limnology specialists will coordinate through the committees on Hydrophysical Environment, Biological Environment and Land Use, and Project Design and Basin Management

b) Input will be needed from the groups on aquatic ecology, water quality, hydrology, climatology

c) Output will be provided for the water quality and ecology groups

4. SCAT will be provided information on physical structure of the aquatic environment.

5. The modeling team will depend on this group for reservoir basin geometry, circulation patterns, and correlations between hydrography and water quality.

6. Required work:

   a) 2000 man-hours

   b) 2000 man-hours

7. Personnel requirements:

   a) Professional (graduate degree, demonstrated capability in fresh water and brackish environs) -- one man

   b) Field/Lab technician (Bachelor's level) -- one man

8. Scheduling:

   a) 1 month

   b) 5 months

   c) $2\frac{1}{2}$ months

   d) 1 month

   e) $1\frac{1}{2}$ month

   f) 1 month

9. Special equipment needs: boat; outboard motor; automated

recording system for bottom profiles, temperature, conductivity, turbidity, dissolved oxygen; current drogues, meters, dyes.

10. Special technical support needed: water analysis lab.

11. A monitoring system for structure of impoundment waters should be designed.

12. The limnology group will concern itself with the impact of intrabasin transfers of water and with the hydrographic impact of decreased flows on the Galveston-Trinity Bay complex.

## PART 12: PEDOLOGY

1. Several categories of information are required from this baseline study.

   a) A major category concerns data on soil nutrients and chemistry as a factor determining the potential status of natural ecosystems and man-made agriculture systems on the land.

   b) A second category is to detail basic soil texture and structure conditions, as a determinant of soil moisture surface hydrology, and plant water supply.

   c) A third category concerns the evaluation of soils data as a factor of importance for engineering considerations.

2. a) The major activity for this study is field sampling and laboratory analysis of data. Sampling patterns will be determined by the natural distribution of ERUs and sub-units, particularly near floodplains, with consideration given especially to regions of prospective development.

3. a) member of committee on Hydrophysical Environments

   b) This study should be performed in close cooperation with the studies of geology (especially engineering geology), geomorphology, hydrology (all types), water quality, agriculture, ecology, and waste disposal.

   c) Soils information is to be a major input in determining source areas for many of the physical and chemical quantities which flow through the hydrologic and ecologic systems of the Trinity River.

4. The soils characteristics - chemistry, texture, structure, engineering conditions, and so forth - should be expressed in considerable detail for each ERU and sub-unit.

5. All major computer modeling will require considerable inputs from soils data. Chemical data will be essential for modeling of water quality and ecosystem materials flows, while physical data is essential for model components dealing with hydrology.

6. a) 4000 man-hours

   b) 4000 man-hours

7. Two professional soil scientists (M.S.level) are needed to work full time during the study, one with expertise in agronomy and soil chemistry, the other with expertise in hydrologic and engineering aspects of soils. Two technicians, for field and laboratory work, will be needed to assist the two full-time soils scientists.

8. Field equipment for soil sampling will be required for this study, with vehicle access to floodplain areas not on roads. Copies of all imagry should be supplied to this project.

9. A soils laboratory, for chemical and physical analyses, should be available for this study; the SCAT soils lab may be more

Copies of existing soils data, much of it as maps or on tape, should be obtained.

10. The work can be scheduled as follows:

a) 1 month

b) 6 months

c) 2½ months

d) 1 month

e) ½ month

f) 1 month

11. No continued monitoring is required, as this study has the basic purpose of obtaining an environmental baseline on basin soils characteristics.

12. Full understanding of the process dynamics within the Trinity Basin requires considerable confidence in information about the distribution of soil properties within the basin, and the role of soils as a determinant of the flows of material (chemicals, nutrients, soil particles, water) through the system. Characterization of the ERUs, and evaluation of land use potential within the basin, is equally dependent on adequate soils data. Thus the pedology study represents one of the most important specialist endeavors within the environmental research plan.

## PART 13: AGRICULTURE

1. These investigations will produce the following primary categories of information:

    a) mapping of agricultural land use including present usage, present trends, and probable future trends

    b) classification and mapping of agricultural land use potential.

    c) designations of those factors necessary for continued and improved agricultural potential (i.e., soil erosion control, improved drainage, fertilization and pesticides)

    d) Conflicting and complimentary interaction between changes brought by the Trinity River Project and agricultural land use potential.

2. These essential data can be gathered by review of agricultural practices and programs within the basin, interviews with county agents and agricultural research units dealing with any areas within the basin.

    a) review existing programs, crop surveys, data.

    b) analyze trends in agricultural land use

    c) mapping of agro-ERUs (past, present, alternative future) and ideal potential agro-land-use

    d) model land uses of the future, with and without various management programs

3. The interrelationsips of agricultural land-use potential,

soil characteristics, and hydrologic characteristics are of greatest importance.

a) The agricultural group will work with the biologic-land use and socio-economic committees.

b) Input will also be supplied from the Forestry, Pedology, Hydrology and Terrestrial Ecology specialists.

c) The Agriculture specialists will provide output to the Forestry, Dredging, Waste Disposal and Economics groups.

4. The Agro-unit will coordinate with SCAT on:

a) agricultural potential of ERUs

b) agricultural conservation needs:

c) distribution (past, present, future) of agro-lands.

5. Data inputs for the computer modeling team will deal primarily with evaluation of suitability of current agricultural land use, distribution of agricultural areas and their cover characteristics and their present management.

6. a) 3680 man-hours

7. Personnel requirements for BEEF: I agricultural specialist (advanced degree; several years' experience; requires knowledge of administration of agricultural programs and practical in-the-field knowledge). One secondary agricultural consultant (degree but less experience).

8. Schedule of progress

a) 3 months

b) none

c) 3 months

d) 3 months

e) 1 month

f) 1 month

9. No special equipment is needed for this study.

10. A copy of all imagry should be provided, with one mirror stereoscope.

11. Periodic revision of agricultural land use, maps will be necessary, for use in basin simulation and economic management efforts.

12. Coordination with other land use studies should be very clear to eliminate duplication of efforts.

## PART 14: FORESTRY

1. Forestry investigations should deal mainly with the following realms of information:
   a) mapping of forest lands under present usage, plus past and probable future trends.
   b) mapping of forest lands by their use potential under alternative management schemes.
   c) designation of those factors and processes necessary for continued and for improved yield of forest products.
   d) complimentary and conflicting interaction between the Trinity River Project and forest-use potential.
   e) status of unmanaged and managed forest areas.
   f) use of forest lands in recreation.
2. These data can be gathered primarily from review of forest management programs and historical data on harvest of forest products and from analysis of air-photos and infrared imagry.
   a) review commercial harvest data.
   b) review of various management schemes, practices, surveys.
   c) analyze trends in forest land use using imagry where possible.
   d) map of forest-products in each ERU and note past and potential future distribution units.
3. Interrelationships of particular importance deal with yield potentials, soil types, and surface drainage.

a) Forestry group coordinates with the committees on Hydrophysical Environment, Biological Environments and Land Use, and Socio-Economic Environments.

b) Other groups providing input to Forestry are Pedology, Hydrology and Terrestrial Ecology.

c) Forestry specialists will also supply input to Agriculture, Economics and Recreation BEEFs.

4. Information to be supplied SCAT are:

a) Distribution of forest products yield, by quality.

b) Distributions of alternative, forest lands of value

c) Previous distrubution of forest lands.

d) Ecologic and management needs for forest-products improved yield.

5. Data inputs will deal primarily with the evaluation of current forest land use and practices, including management models.

6. a) 1760 man-hours

b) 1760 man-hours

7. Personnel requirements:

a) One Forestry specialist (graduate degree with experience in both administrative and field aspects of forest management).

b) Field and reconnaissance technician (with formal training).

8. Schedule of progress:

a) 2 months

b) $1\frac{1}{2}$ month

c) 3 months

d) $1\frac{1}{2}$ months

e) 1 month

f) 1 month

9. No special equipment needed for this study.

10. Remote sensing imagry should be supplied to this study team.

11. Periodic revision of maps for forest land use are necessary for basin simulation and economic management studies.

12. Comments: see Part 13.

13. (Agriculture)

## PART 15: TERRESTRIAL ECOLOGY

1. The primary categories of information to be gathered from these studies are:

   a) species composition of ERUs

   b) approximate distribution of major species...that is, any populations comprising a significant portion of materials/energy - storage pools or exerting a sizable influence on energy flow pathways, materials cycling or successional trends

   c) basic structuring of the ecosystem...that is, flow direction of materials and energy, and transport mechanisms

   d) boundaries of those systems which provide significant contribution of materials/energy to the lotic environment

   e) quantification of materials/energy cycling and flows in those systems

   f) quantification of materials/energy cycling and flows in sub-systems essential to maintenance of populations of economic importance or target populations of government and/or private conservation efforts

   g) successional stages and trends of each sub-system unit

2. Activities of this phase will be as follows, in order of their performance:

   a) identification and distribution of flora and fauna

b) field and remote sensing measurement of standing crop, production and decomposition rates;

c) interpret above in view of hydrologic, geologic, climatologic processes and changing human activities;

d) identify and quantify transport mechanism by which materials/energy are removed from the basin terrestrial ecosystems

e) coordinate with generalist mapping team, modeling team and other specialists (i.e. hydrology, pedology, aquatic ecology, forestry, agriculture)

3. Of particular importance are the interrelationships of productivity, materials/energy transport and succession to those processes which stand greatest probability of being altered by components of the Trinity River Project. Examples of these are changes in: water-table level, frequency of flooding, run-off rates due to denudation.

a) to be represented on Biological Environments and Land Use committee

b) to receive input from pedology, agriculture, forestry specialist groups

c) to provide consultation for agriculture, forestry, wildlife management, archaeology groups

4. Mapping of ERUs may be benefitted by greater detail in floral composition and distribution, interpretation of successional development and understanding of interdependence of units

5. Computer modeling of the terrestrial-lotic interface may be elucidated by a better definition of terrestrial materials transported to the lotic environment and a better understanding (quantification) of transport phenomena and origins.

6. Required work:

   a) 6,000 man-hours

   b) 4,000 man-hours

7. Full-time personnel required includes a systems ecologist as field supervisor, and two other professionals - a plant ecologist and an animal ecologist - both with expertise in the areas of productivity and mineral cycling. One should be extremely familiar with forest-grassland organic turnover and decomposition phenomena. Field support by at least two biologist-technicians will be necessary.

8. Approximate scheduling: Total duration 12 - 13 months.

   a) 1 month

   b) 5 months (technicians work longer)

   c) 2 months

   d) 2 months

   e) 1 month

   f) 1 month

9. Equipment needs include the usual array of field sampling gear, basic laboratory equipment for weighing, measuring and some analytical chemical back-up. Instrumented techniques for estimating standing crop, productivity, etc., will greatly increase the benefit-cost

factor of these studies and reduce time requirements. A four-wheel drive vehicle will be necessary to assure year round access to the field.

10. No special support requiring technological improvements are necessary. Technical support should concern mainly the efficient collection and transport of samples to the laboratory and handling of large volumes of data. Computer time (in addition to overall modeling efforts) will be necessary, as will some analytical chemical back-up capability, and copies of all remote sensing imagry.

11. Monitoring of stream-borne materials and energy of terrestrial origin is a facet which should be planned for the duration of project construction and thereafter as a management consideration. Related to these sources are the successional trend of sub-systems' stream water quality, and changes in faunal and floral composition resulting from the project and its socio-economic impact.

12. It must be kept in mind that for fullest consideration of alternatives, not only should existing trends and characteristics of the basin ecosystem be considered, but also potentials under varions use-criteria. These activities must also be coordinated with the aquatic ecology, forestry, agricultural, wildlife management and water quality studies to avoid duplication and maximize information generated.

## PART 16: AQUATIC ECOLOGY

1. The primary categories of information to be gathered from these studies are:

    a) species composition and distribution - that is, which populations are restricted from or confined to particular stream reaches

    b) origin, transport and fate of materials/energy. (allochthonous sources, autochthonous contribution, nutrient cycles, trophic efficiencies, etc.)

    c) relate above rate-processes to floral and faunal distribution and population sizes (permitting relation to water quality, flow characteristics, land use, etc.)

    d) determine energy resources available to fishery populations of economic importance, both riparian and estaurine

    e) determine which populations are restricted or encouraged by manageable/unmanageable processes

2. Activities will be as follows:

    a) identification, distribution, population success of flora and fauna

    b) field measurement of materials/energy transport rates and storage reservoirs, production, decomposition

    c) interpret above in view of climatologic, hydrologic, sedimentologic processes, water quality, stream geometry, and human activities.

d) identify and quantify mechanisms and routes by which materials/energy are carried through the lotic system and into the estaurine system

e) coordinate with generalist mapping team, computer modeling team and other specialist groups (especially water quality, terrestrial ecology, wildlife management, fishery management, limnology and oceanography and hydrology studies)

3. Of particular importance are the interrelationships of point/reach sources of materials/energy; hydrologic phenomena and materials turnover; and the sediments as a temporary or permanent storage unit for biologically active materials. These are areas that will be most influenced by project construction and implementation (i.e. channel straightening, flow control, and industrial activities in the flood-plain resulting from navigational use.)

   a) Biological Environments and Land Use committee

   b) input from limnology, hydrology,water quality and terrestrial ecology groups

   c) output for groups on fisheries management, water quality, limnology and oceanography

4. Contribution may be made to ERU mapping efforts by provision of species distribution data; understanding biologic processes as they relate to stream order,other purely physical measurements; and sequential fluxing of materials through downstream units.

5. Computer modeling of stream transport characteristics as influenced by rate-processes (community metabolism, faunal migration, biologic uptake) will be primarily dependent upon these specialist activities and their coordination with water quality, limnological and oceanographic studies.

6. Required work hours are as follows:
   a) professional-4,000
   b) technical-4,000

7. Two full-time aquatic systems ecologists will be required for one year, along with two junior biologists or biologist-technicians.

8. Approximate scheduling:
   a) 1 month
   b) 5 months (in two parts)
   c) 3 months
   d) 2 months
   e) 1 month
   f) 1 month

9. Equipment needs include two small boats: outboard motors, trailer and four-wheel drive vehicle to assure year-round access to the field. Instrumented portable systems for continuous measuring and recording of temperature, oxygen, bottom samplers and water samplers will be needed. Other equipment associated with the biological laboratory is required.

10. Technical support in the form of analytical chemical back-up, wai .

quality data, and hydrologic data will be essential. Computer time will be needed to process data.

11. Monitoring of certain biological features (faunal distribution, productivity, nutrient cycling, decomposition) will be essential to a continuous management program, but which features are to be selected depends upon management goals from the biological standpoint.

12. The inclusion of sampling for faunal and floral populations should be restricted to collection of as quantitative data as possible. Since quantitative data on planktonic populations require a great deal of sampling and laboratory examination, it is best to confine their consideration (in the interest of expediency) to evaluation of certain indices which are indicative of the size and composition of these communities. Examples of such indices are cell biomass or standing crop, pigment concentrations and ratios, biochemical diversity indices, community metabolism, material turnover rates and efficiency ratios between trophic levels. Complex sampling programs to enumerate populations and identify individual species are of limited value in expressing functional roles of these ecosystem components while such an approach can lead quite rapidly to costly and timely field and laboratory work. In view of the potential yield of such efforts, they should be kept to a minimum.

As in the terrestrial ecology studies, attention should be extended beyond existing trends and characteristics to include projections of potential conditions under alternative use-criteria. Coordination with other specialist activities, particularly limnology and oceanography, hydrology, fish and wildlife, and water quality will permit maximum utility of data.

## PART 17: WILDLIFE MANAGEMENT

1. These investigations will produce the following primary categories of data:
    a) approximate distributions of important wildlife species and rare/endangered species or other populations of special aesthetic or scientific interest
    b) annual production and harvest of game species (resident and migratory) within the basin, by a breakdown consistent with ERUs; under present and alternative management systems
    c) primary areas important as reproductive sites, migratory routes, wintering areas, feeding areas
    d) policies, practices or ecologic conditions which are essential to sustained or improved yield in each ERU
    e) policies, practices or ecologic conditions which are detrimental, essential or limiting to sustained game yields or improved yields for each ERU
2. Most essential information can be gathered by review of basin wildlife management programs, state and federal wildlife agencies' data on surveys, game harvests, pilot projects, etc. Field surveys are generally not essential but if needed for certain areas can be performed in conjunction with terrestrial and/or aquatic ecology field work.
3. Of particular importance to wildlife production for an ERU are land-use practices and land owner policies in adjacent and nearby areas;

and available food and cover within the ERU.

a) to be represented on Biological Environment and Land Use and Socio-Economic Environment committees

b) to receive input from terrestrial ecology, forestry, hydrology groups

c) to provide output for groups on economics, terrestrial ecology, forestry, agriculture

4. Contribution to the generalist ERU mapping team will deal with wildlife yield and potential yields.

5. Limited input will be provided for the computer modeling efforts, dealing primarily with wildlife production and harvest. Of greater importance will be input to economic modeling and coordination with the terrestrial and aquatic ecology groups.

6. Required work:

a) 1,500 man-hours

b) none

7. One wildlife biologist, familiar with basin geography and data sources; and capable of conducting independent thought and work.

8. Scheduling:

a) 5 months

b) none

c) 2 months

d) 1 month

e) 1 month

f) 1 month

9. No special equipment is needed.

10. Technical support is limited to data acquisition; access to terrestrial ecology groups data and activities.

11. Monitoring anticipated after completion of study may come primarily as recommendations to applicable agencies for improvement or modification of existing survey and reporting techniques, and additional investigations of particular interest in specific areas.

12. Comments: valuable resources identified by this study must be protected from misuse in basin development.

## PART 18: FISHERIES MANAGEMENT

1. This specialist group will deal with the following categories of data:

   a) Distribution of important sport and commercial fishery species and rare/endangered species or other populations of special aesthetic or scientific interest

   b) Past and present harvests of game and commercial species by ERUs and potential harvests under alternative management programs.

   c) Primary areas important as spawning nursery and feeding sites and as migratory routes

   d) Policies, practices or ecologic conditions essential to sustained or improved yield in each ERU.

   e) Policies, practices or ecologic conditions detrimental or limiting to sustained or improved yields for each ERU

2. Most of this information can be collected by review of state and federal conservation agency management and surveillance programs, creel censuses, research records, etc. Field surveys are generally not needed but if adjudged to be for certain areas, these can be performed in conjunction with the aquatic ecology field team.

3. Of particular importance to fisheries production are stream water quality, ecosystem energetics and water flow characteristics.

   a) The fisheries management unit is assigned to the committees on Biologic Environments, and Land Use and Socio-Economics

b) Input should be received from the water quality, aquatic ecology, and limnology groups.

c) Output will be provided to the aquatic ecology and economics groups

4. Contribution to the ERU mapping team will deal with fishery products, potential yields and fishing pressure.

5. Limited input will be provided for the computer modeling efforts, dealing primarily with fisheries production and harvest. Of greater importance will be input to economic modeling.

6. a) 1500 man-hours

   b) none

7. One senior fishery biologist, familiar with basin programs, geology and data sources will be needed to conduct the review.

8. Scheduling:

   a) 1 month

   b) none

   c) 5 months

   d) ½ month

   e) 2 months

   f) ½ month

9. No special equipment is needed

10. Technical support is limited to data acquisition,

11. Anticipated monitoring after completion of study may come primarily as recommendations to applicable agencies for improvement or modification of existing survey and reporting techniques, and additional considerations of particular interest in specific areas.

12. Fisheries resources should be protected as part of basin management.

## PART 19: RECREATION

1. Information required as part of this study concerns:

    a) Recreational facilities existing or planned within the basin, and data on the trends in use of these facilities, e.g. relative changes in use for various land and water activities

    b) In addition a full survey of potential "wilderness" areas is needed, to locate and describe regions within the basin which presently are in a semi-natural or natural state

    c) A survey should locate and describe areas of value to environmental education, e.g. areas for nature trails

    d) A survey of the recreational wants and needs of Trinitarians is required

    e) Finally, an inventory of the pollution effects of recreation should be attempted, so that pollution related to project-developed recreation can be analyzed

2. The major activity of this study will be to survey existing records concerning recreational facilities and usage within the basin, and to prepare and implement the survey of recreational wants and needs. Some field work, involving visits to areas of unique value for wilderness or educational purposes, will be required.

3. a) member of committee on Biological Environment and Land Use; member of committee on Socio-Economic Environment

member of committee on Project Design and Basin Management

4. The recreational use and values of each ERU should be designated, and land use optimums should consider these values.

5. Major data for computer modeling will be projected recreational land use, with probable changes in water quality associated with activities such as power boating.

6. a) 1000 man-hours

   b) none

7. One recreational specialist (M.S. level) is needed for the study.

8. No special equipment is required for the study.

9. No technical support is needed for the study.

10. The scheduling can be as follows:

    a) 2 months

    b) 1 month

    c) 2 months

    d) ½ month

    e) 1 month

    f) ½ month

11. After the specialist survey is completed, future planning should continue to evaluate recreational needs and uses.

12. As an avowed goal of the project to improve recreation, this

study represents an important component of the specialist research, especially in evaluating the actual long-term effect of the project.

## PART 20: ARCHAEOLOGY

1. Information to be gathered by the archaeology task force differs considerably from a conventional type of archaeological survey. The following categories are primary:

   a) Location of sites

   b) Identify anthropological or archaeologic problems relative to each site

   c) Appraisal of the quantity/value of data to be yielded from sites relative to each problem

   d) Probable occurrence of types of material present at each site (not relics or artifacts, but rather faunal and floral remains)

   e) Approximate geologic and ecologic context within which each site appears

   f) Quantification of total archaeologic resources and physical relation to project activities (i.e., subject to flooding, excavation, partial burial, etc.)

   g) Cost estimates of recovery (alternative degrees of recovery from complete recovery to complete abandonment) to be viewed relative to appraised data yield per degree of recovery

2. Activities required for archaeologic task force are:

a) Site locations by:

1. Review aerial photography

2. Field search

b) Partial excavation to determine extent of sites and probable occurrence of remains

c) Determine geologic and ecologic context within which sites occur by consultation/field visit with members of geology and ecology task forces

d) Review of field data in view of existing literature

e) Conduct appraisals and cost estimates.

f) Preparation of reports.

3. Of particular importance are the relationships between site location and settlement environment; also of site locations with proximity of various construction activity and projected land-uses.

a) To be on Socio-Economic Environment Committee

b) Input from geology and terrestrial ecology groups

4. There will be no input to the ERU mapping task force. Site locations should not become part of a document for public release.

5. There will be no input to the computer modeling, but rather to the economic modeling efforts.

6. Required work:

   a) 4000 man-hours

   b) 2500 man-hours, including laborers

7. This task force should consist of two experienced field archaeologists and their two assistants for a period of nine months. Two to three laborers will be needed for several weeks each when the group leader determines partial rough excavations are timely. Consultation time from the geology, pedology and ecology groups will be necessary.

8. Most of the field work of this task force must be conducted during winter months, because of difficulty in locating sites in a heavily vegetated flood-plain; intended excavations may be held off until summer months.

   a) 1 month

   b) 6 months

   c) 2 months

   d) none

   e) 1 month

   f) 1 month

9. There are no special equipment needs except for a field vehicle, photographic and survey instruments.

10 Special technical support required includes occasional analytical chemical.

11 Monitoring, or field observations should continue for those sites adjudged to be of adequate value to warrant excavation, especially when in the proximity of construction activity. Further watch should be conducted for sites not already exposed at the surface, but which may become exposed during construction.

12 The site survey and appraisals suggested here are quite different from archaeologic surveys as normally thought of. It must be understood that this is not a salvage effort nor is the archaeologist recommending salvage. He must also avoid too literal an interpretation of NEPA's "recovery of archaeological and historical specimens". The real value of archaeological discovery to man does not lie in the worth of artifacts as collector's items.

## PART 21: HISTORICAL AND SCENIC SITES

1. The Trinity Basin must be surveyed in order to completely locate and describe all sites and areas which have public values, e.g. for historical or scenic reasons. Where particular sites are endangered by project activities, detailed analysis of site character is required, to fully document site value. In this way the merits of site preservation,protection, or "intact" movement can be judged versus the merits of continuing the project with no changes. In many cases it should prove possible to reconcile project goals with the public values determined by this study.

2. One activity is to analyze the scenery of the Trinity Basin, and to identify any regions which have a character that is unique and/or particularly aesthetic. Descriptions of these regions are required, with particular attention to areas in floodplains or at proposed reservoir sites.

   Similarly an inventory of historical sites within the basin is needed, with field investigation of key areas to uncover as yet uncatalogued sites which might be affected by the project.

3. a) member of committee on Socio-Economic Environment

   b) input from study on archaeology

   c) inputs to project design and basin design

4. No input to ERU mapping will result from this specialist study.

5. Historical and scenic considerations will be involved where land values are calculated for input to computer models.

6. a) 1,500 man-hours

   b) none

7. One person, familiar with problems of evaluating landscape aesthetics and historical site values, should work nine months on this study. The study should involve cooperation with responsible citizens groups interested in environmental issues.

8. Remote sensing imagry should be supplied for the study of scenic sites.

9. No special technical support will be needed.

10. Scheduling should be as follows:

    a) 2 months

    b) 1-1/2 months

    c) 2-1/2 months

    d) none

    e) 2 months

    f) 1 month

11. No minitoring is required for the study, but protective surveillance of valuable sites should be incorporated into planning of the completed project.

12. No actual development of sites is anticipated from this study, but merely the accurate inventory of valuable sites within the basin, so that project planning can be adjusted where necessary, or so that

sites can be protected from the consequences of construction, flooding, or development.

## PART 22: WATER SUPPLY AND USE

1. This study should obtain information on:
   a) quantity and quality of water resources available to basin today, and in the future, with and without the project
   b) mechanisms for water supply and treatment; administration and rate structures associated with the water industry
   c) details of all proposed changes in water conditions within the basin, including planned diversions, inter-basin transfers, aquifer mining, construction of reservoirs
2. The primary activity of this study will be the careful review of existing data on water supply within the basin, and projections of future conditions.
3. a) member of committee on Biological Environment and Land Use; member of committee on Socio-Economic Environment; member of committee on Project Design and Basin Management
   b) this study should obtain input from all research related to basin hydrology, and research on land-use trends
   c) this analysis should provide input for basin management studies
4. Water supply resources in each ERU should be specified.
5. Data on water transfers within the basin should be used as part of hydrologic modeling of basin.

6. a) 1,000 man-hours

   b) none

7. One experienced water resources engineers should work six months on this study.

8. a) 2 months

   b) none

   c) 2 months

   d) 1/2 month

   e) 1 month

   f) 1/2 month

9. No special equipment is needed for the study.

10. Access to statistical processing will be required.

11. Advice on monitoring of water transfers may result from this research.

12. This research may involve only the outside review of existing reports for basin water supplies, e.g. detailed information that is part of the Trinity River Authority Master Plan.

## PART 23: CONSTRUCTION

1. Information is required on:

   a) volume of construction materials (e.g. sand and gravel)

   b) source areas of materials

   c) grading needed at construction sites

   d) volume of spoil generated by construction

   e) environmental impact of construction, excavation of materials, and emplacement of spoil

   f) changes in design specifications which can lessen environmental impacts

2. The major activities required are:

   a) review of design specifications for project components, checking estimates on earth-moving and earth material magnitudes

   b) check on site and near site geology to ascertain sources of needed materials, and to note any construction problems

   c) model the environmental impact (e.g. silt generation) resulting from construction projects

3. a) member of committees on Hydrophysical Environment and Project Design and Management

   b) input to this study will come mainly from project designs, and studies concerned with floodplain characteristics

   c) this research will generate material for all studies concerned with floodplain environments

4. No direct input to ERU mapping is anticipated.

5. Computer modeling should consider effects of construction on water quality.

6. a) 1,000 man-hours

   b) none

7. One person, preferably a Professional Engineer, should work six months on this study.

8. a) 1-1/2 months

   b) 1/2 month

   c) 2-1/2 months

   d) 1/2 month

   e) 1/2 month

   f) 1/2 month

9. No special equipment is needed for this study.

10. Copies of imagry for floodplain areas, and copies of project designs should be provided for this research.

11. No monitoring is required as part of this study.

12. The study is of a reconnaissance area, and detailed confirmation of site conditions is required before construction begins.

## PART 24: DREDGING

1. The study of dredging is needed to determine areas where channel maintenance will be required. The research should yield calculations of the volume of material involved in dredging, and must consider the effects of dredging activities on the environment. Sites for disposal of spoil must be evaluated.

2. a) the initial activity will be to evaluate all information on siltation within the basin, with attention directed to each reach of the river

   b) project design specifications, when compared to natural silt problems, shoudl permit estimation of dredging requirements resulting from project completion

   c) reaches where major dredging is needed should be studied in detail, to determine control measures which might alleviate the problems, and to locate sites where excess load will be stored

   d) the final activity will be to model the environmental impacts of dredging activities, i.e. the impact of channel maintenance. In particular the effects on aquatic ecosystems must be carefully considered

3. a) member of the committes on Hydrophysical Environment and on Project Design and Basin Management

b) input will come from all research concerned with physical conditions within the basin, especially those related to sediment supply (hydrology, geomorphology, stream sediment dynamics, land-use).

c) output will be especially relevant for research on lotic ecosystems and fluvial geomorphology

4. There is no output to ERU mapping.

5. Quantitative information on the effect of channel maintenance on stream sediment movement should be incorporated into the basin model.

6. a) 1,000 man-hours

   b) none

7. One Professional Engineer, experienced in channelization projects, should work six months on this study.

8. a) 1-1/2 months

   b) 1/2 months

   c) 2 months

   d) 1/2 month

   e) 1 month

   f) 1/2 month

9. No special equipment is needed for the study.

10. Copies of pertinent imagry and design plans should be supplied for this research.

11. No monitoring is required.

12. This research is not meant to duplicate or eliminate the need for detailed site examination and planning.

## PART 25: WASTE DISPOSAL

1. The waste disposal study group should establish the following information and concepts:

   a) Inventory of existing sewage treatment practices and capability in the basin

   b) Projections of future needs for sewage treatment in the basin with and without the project

   c) Inventory existing solid waste production and disposal practices in the basin

   d) Projections of future solid waste production in the basin, with and without the project

   e) Inventory of industrial waste discharges in the basin and projection of future discharges with and without the project

   f) Opportunities for regional management and treatment of sewage and industrial wastes in the basin, with and without the project (i.e., spray irrigation, etc.)

   g) Opportunities for regional solid waste management in the basin, with and without the project (i.e., barging to better suited fill sites, recycling plants, etc.)

   h) Impact of present waste management practices on environmental quality, with and without the project.

   i) Waste management practices which need to be revised to assure continued environmental quality when the project is completed.

2. The above information can be obtained by:

   a) review of existing waste management practices and magnitudes under jurisdiction of state agencies, municipalities, regional councils of governments, and counties

   b) extrapolation of per capita increase in waste production from present to future alternative population estimates

   c) evaluation of sewage management procedures and technology, present and future, which could be used to improve basin environment

3. Interrelationships to be concerned with are water quality, usage of ground water sources, transportation facilities, and basin population and industrial growth.

   a) The waste management study group is on the Project Design and Basin Management committee.

   b) Input will be provided by the water quality, transport, water supply and use and other groups.

   c) The waste disposal specialist will provide input to the groups studying regional planning, economics, water quality, and other studies of basin management.

4. There will be no input to the ERU mapping but SCAT will be provided information on waste production estimates.

5. The modeling group will be provided waste production estimates for alternative development schedules for economic modeling.

6. Required work:

   a) 1000 man-hours

   b) None

7. The study-group will consist of one sanitary engineer, with a graduate degree and demonstrated ability to generate innovative thought.

8. Scheduling:

   a) 1½ months

   b) none

   c) 2½ months

   d) ½ month

   e) 1 month

   f) ½ month

9. No special equipment will be needed.

10. No special technical support will be required.

11. Reporting of innovations and changes in regional waste management practices will be required for basin management to assure environmental quality.

## PART 26: PUBLIC HEALTH

1. For this study information is needed to:

   a) Establish existing levels and trends in public health parameters within the basin, particularly those related to water quality.

   b) Evaluate effect of project on public health, with particular consideration given to vector populations, water toxicity, and air contamination.

   c) Design guidelines for project management in order to maximize public health conditions

2. The major activity of the study will be to evaluate existing data on public health, water quality, vector populations, waste generation, air quality, and other factors important in determining the health and welfare of the public. Careful scrutiny of the parameters which control public health will permit identification of probable impacts due to project completion, and thus, should enable management decisions designed to mitigate against these impacts. Sampling in key areas may be needed.

3. a) Member of committee on Socio-Economic Environment

   b) This study should receive input from other research on water quality, air quality, water supply and waste disposal

   c) Output from this study may be of value to research concerning water supply, water quality, and project design

4. No input to ERU mapping is envisaged.

5. Some quantification of health hazards may be put into computer models.

6. a) 1000 hours

   b) none

7. One person with extensive public health experience should work six months on this study; an M.D. would be the optimum choice.

8. a) 2 months

   b) 1/2 month

   c) 1 1/2 months

   d) 1/2 month

   e) 1 month

   f) 1/2 month

9. No special equipment is required for this study.

10. No special technical support is required, although analysis of some water samples might be useful in the research.

11. Guidelines established by this study should be included in the surveillance program which continues after the research is completed.

12. It is essential that public health problems be considered in detail, in order to forestall any negative effects which could arise from completion of the Trinity River Project, and in order to document improvements directly tied to the Project.

## PART 27: REGIONAL PLANNING

1. The primary categories of information to be gathered from this specialist study are:

   a) trends in land use in the Trinity River Basin, especially industrial and urban uses; planned changes in land use within the basin

   b) demographic structure within the basin, including rates of growth and diverse patterns of dispersion:

   c) values of land of various categories throughout the area, including land to be displaced by project components

   d) additional information from other studies should be included in the analysis of regional land use, e.g. economic data (employment, income, financial controls of development), agricultural land use, forestry, recreational requirements for land, transportation systems, legal structures, etc.

   e) consideration should be given to the overall environmental impact of development resulting from the completion of the project

2. Activities followed during the study include:

   a) investigation of past records and current maps of federal, state, and local governmental agencies concerned with planning or development; similarly contact with community groups, and business associations

   b) use maps and photos to determine land use conditions in each ERU and sub-unit

c) investigate proposed land use changes in the future, including federal and other grants being used for planning proposed within the basin

d) characterize and model land use changes within the basin, especially rates of land going out of agricultural use and land going into urban or industrial uses

e) determine effect of project on planning, including development hindered by project, and development which assumes specific project schedules

f) ascertain probable future requirements for housing facilities, schools, religious structures, and other special land uses; analyze present zoning structures and possible future needs

g) use assessment techniques to determine land values, before and after project completion, and indicate possible windfalls accruing to individual or corporate speculators

h) characterize architectural trends in basin, and other factors which might affect aesthetic values in floodplain regions

3. a) member of committee on Socio-Economic Environment; member of committee on Project Design and Basin Management

b) much input will be received from studies of transportation, historical and scenic sites, recreation, public health, water supply, waste disposal, economic, sociology, and laws and public administration, among others

c) output will primarily be in the form of land use changes and needs for the future; this information will be of value to all studies in which project impact is to be evaluated (e.g. research on needs for floodplain management, flood control, recreation, etc.)

4. The land use patterns typical of each ERU should be determined. The qualitative synthesis made by SCAT should depend heavily on information on regional planning that is derived from this study.

5. Computer processing of land use and land values should be part of the basin model.

6. a) 4,000 hours

   b) none

7. Two full-time professional planners should be obtained for this study. Persons with degrees in planning, rather than in architecture, should be sought.

8. a) 4 months

   b) 1 month

   c) 3 months

   d) 1 month

   e) 2 months

   f) 1 month

9. No special equipment is required.

10. Copies of all imagry should be available for this study (with stereoscopic equipment). Extensive access to cartographic services will be necessary.

11. Precautionary planning and zoning should control growth patterns; surveillance of these patterns is recommended.

12. It is important that the regional planning staff have the capability to interact with the many other BEEF specialists, in order that regional growth interactspositively with natural conditions within the basin.

# PART 28: ECONOMICS

1. The study will broaden the traditional cost/benefit analysis of the project to include estimates of:
   a) immediate economic benefits of the construction
   b) immediate economic costs of the project -- destruction of existing economic resources
   c) long-term economic benefits derived from economic use of the project -- resulting shipping, changing patterns of land use, and installation of privately financed new economic resources
   d) resulting changes in land values, income levels, population, occupational status, etc.
   e) long-term economic export impact on the surrounding regions
2. The main activities of the study will be:
   a) review of all existing economic impact material including past studies and publications by the Trinity River Authority, the U. S. Corps of Engineers, the State of Texas, North Texas Council of Governments, and other agencies
   b) gathering of significant economic data for each of the counties in the Authority
   c) inventory of existing economic resources which will be destroyed by completion of the project

d) development of a statistical computer simulation model to study the impact of the project

3. a) member of committee on Socio-Economic Environment

   b) input will be derived from studies of land-use, basin management, sociology, transport, water supply, waste disposal, and related studies

   c) this study will provide input for research on sociology, transport, and all analyses of land-use planning

4. Any characteristic economic conditions of an ERU will be specified.

5. Computer modeling of economic structures in the basin will include:

   a) population

   b) effective buying power

   c) retail sales estimates

   d) employment

   e) school enrollment

   f) cash receipts from farm marketing

   g) employment by industry

   h) taxable payrolls by major industry

6. a) 4,000 man-hours

   b) 1,000 man-hours

7. Two professional economists, at the Ph.D. level are required. A technical assistant, skilled in modeling, should be utilized for a six month period.

8. a) 5 months

b) 1 month (concurrently with a)

c) 4 months

d) 4 months (concurrently with c)

e) 2 months

f) 1 month

9. No special equipment required.

10. Considerable access to computing time will be required.

11. No monitoring is needed.

12. The economic analysis, like others in BEEF, will depart from traditional studies, in which political units are often the core, to concentrate on the Trinity River watershed as a vital economic entity.

## PART 29: TRANSPORT

1. Information to be sought by this BEEF specialist study includes:

   a) Present status of transportation systems within the basin, and trends in transport use and rates

   b) Planned developments affecting transportation, including highway construction, airports, and canals

   c) Needs of the basin regarding passenger and freight movements, and evaluation of planned developments in terms of these needs

   d) Characterization of the barge transport systems which will result from completion of Trinity River Project - efficiency of system, economics (including rate structures), effects on environment

   e) Evaluation of systems competing with barge traffic - including comparison of environmental impacts and comparison of value in fulfilling community needs

2. Activities to be pursued in this study include:

   a) Gather full data on present transportation systems in the basin, determining costs and convenience of passenger and freight movement by water, truck, automobile, bus, railroad and air

b) Scrutinize the proposed barge traffic system, and fully evaluate costs, environmental impacts, and economic development related to the system. Particular attention must be paid to the effect of barge movement on air and water quality, and mechanisms by which this effect can be lessened

c) Investigate planned and feasible alternative transportation systems, along the same outlines as (b). Determine if any regional goals for transport exists, and what systems fit best with these goals

d) Study projections of development to be brought about by barges, and evaluate environmental impact of same (e.g., riverside facilities, industrial facilities)

3. a) Member of committees on Socio-Economic Environment and Project Design and Basin Management

b) Input will be received from studies of basin land-use, economics, and other socio-economic research projects

c) This study will generate information needed in analysis of water quality, air quality, regional planning, economics, and all studies concerned with environmental impacts along the main channel and flood-plain

4. No specific input to ERU mapping is envisaged.

5. Data from this study will be used as inputs to models of water quality, and to modeling of land use and economic structures within the basin.

6. a) 1500 man-hours

   b) none

7. One professional, experienced in evaluation of transportation systems, should be used in this study. This person should be expert in transport economics and management and familiar with barge systems, and capable of original insights on transport management.

8. a) 3 months

   b) none

   c) 3 months

   d) 1 month

   e) 2 months

   f) 1 month

9. No special equipment is required for the study.

10. Access to statistical testing equipment will be needed.

11. No monitoring will result from this study.

12. Public sensitivity on environmental issues has often been directed against projects devised for navigation purposes. Thus, the study outlined above is vital, for development of the Trinity Basin cannot proceed, in the form presently conceived, unless the barge transport system can be shown unequivocally to be economically feasible and environmentally sound.

## PART 30: LAW AND ADMINISTRATION

1. The primary categories of information to be gathered from these studies are:

   a) determine federal, state, and local laws that will affect the basin.

      (i) identify the various categories of laws affecting the basin

      (ii) identify the precise effects the various laws will produce on the basin

   b) determine all federal, state, regional, and local agencies that will have regulatory jurisdiction over the basin

      (i) identify the various agencies at the federal, state, regional, and local level that will have regulatory power over the basin

      (ii) identify agency policies and regulations that will significantly affect the basin and the nature and extent of said effects

   c) determine the optimum type of governing body needed to regulate and control the basin

      (i) what type of governing body is required to manage the basin project

      (ii) should the governing body be a state, regional, or local agency

      (iii) what relationship should the selected governing body have to the various federal, state, regional, and local agencies having control over basin activities and the project.

(iv) how should the basin governing mechanism be structured in light of the function to be performed by said governing mechanism

(v) should the agency be managed by a single administrator appointed by the Governor or by a commission

(vi) what powers should be granted to the basin regulatory authority: should the agency have only planning powers; should the agency have enforcement powers; should the agency have financing powers (power to issue bonds, levy taxes)

(vii) what should be the scope and extent of the powers granted to the basin agency

(viii) should the jurisdiction of the agency cover environmental matters and if so to what extent

(ix) what relationship should the agency have to federal, state, regional, or local environmental agencies in terms of jurisdiction over pollution problems

(x) what zoning powers should the agency have, if any

d) this analysis should carefully examine whether the

Trinity River Authority (TRA) is the appropriate body to manage both the project and the environmental problems of the entire basin

(i) should the TRA manage the project and have jurisdiction over environmental problems in the basin

(ii) does TRA have sufficient power to manage the project

(iii) if not, what other powers should TRA be granted to manage the project and/or environmental problems of the basin

(iv) legislation needed to create the basin regulatory agency if, in fact, a new agency is required: determine substance and content of legislation; ascertain appropriate senators and representatives to submit and back legislation

(v) determine plan to inform public on the progress of the project to generate proper political support

2. Activities will be as follows:

a) survey laws and agencies that will affect the basin project via literature search and possibly interviews

b) inventory effects applicable laws and agencies will have on the basin project via literature search and interviews with administrators of concerned agencies

c) identify appropriate structure and powers of the basin agency

(i) review literature to determine structure and powers of regional agencies located in other states (for example, Lake Tahoe regional control agency)

(ii) contact administrators with federal, state, regional, and local environmental agencies having jurisdiction over the basin and/or the project

(iii) contact consulting firms and university professors who have done work on the concept of regional control agencies

d) draft legislation creating the basin agency or modifying powers of the existing agency selected to manage the basin and/or the project, if needed

(i) review legislation from other jurisdictions that created similar regional control agencies

(ii) visit with experts on legislative drafting to determine form of bill to be drawn

e) formulate political strategy needed to generate appropriate support for the basin project

3. a) Members of committees on Socio-Economic Environment, and Project Design and Basin management

b) Study of agency structure should consider input from other BEEF specialists concerning diverse environmental problems and functions required for proper basin management

c) This study will provide output of importance to projections of future conditions in the basin, e.g. water quality, aquatic ecosystems, transport, regional planning

4. No input to ERU mapping is anticipated.

5. No input to computer modeling is anticipated.

6. a) 2000 man-hours

   b) 1000 man-hours

7. This study requires an experienced attorney with expertise in environmental matters and administrative law. A law student or recent graduate can provide the technical assistance.

8. a) 1 month

   b) none

   c) 10 months (including formulation of agency structure, legislation)

   d) none

   e) none (as such)

   f) 1 month

9. No special equipment is needed.

10. No special technical support is required.

11. No monitoring is required; it is hoped that the agency will be authorized and can begin comprehensive basin monitoring and management.

12. Great care should be given to determining the type and

structure of the agency selected to manage the project and/or environmental problems of the basin. If the agency configuration and powers are not compatible with the objectives of the project, the failure of the project will be insured and will occur rapidly. In order to insure that the agency structure is appropriate for implementing the goals of the project, the attorney retained to perform the analysis should periodically review his ideas with the various members working in alternative disciplines.

## PART 31: SOCIOLOGY

1. The study of sociology by BEEF specialists must determine the following information:
   a) population and existing social structures within the Trinity River Basin, public actions
   b) established goals of society and changes in these goals
   c) quality of life within the basin, and prediction of changes affecting each social group, i.e. present trends in sociological parameters
   d) benefits and problems of project completion, increased basin development and urbanization, including effect on different special interest groups (ethnic groups, business organizations) and on society as a whole
2. Activities that are part of this study are:
   a) make a demographic study of the entire basin, determining how the existing population is dispersed, and indicating income levels, social levels, migration trends, and related information
   b) survey needs of the society, as articulated by citizens within the watershed
   c) determine goals of regional planning which can provide for the social needs of the area

d) evaluate how the Trinity River Project will affect economic well-being, environmental quality, and other parameters which determine quality of life within the basin. In particular stress the effects of increasing urbanization and population concentration

e) determine increased demand for services resulting from basin development - safety forces, schools, parks, churches - structure for providing these services, and stress on society (e.g. taxation) related to the development

f) define all cultural features of area which need to be protected against radical changes in the basin environment

g) predict social conditions existing after completion of the project (e.g. distribution of population geographically and by economic level) and ascertain the degree to which contemporary planning will serve the needs of society at that time

3. a) member of committee on Socio-Economic Environment

b) input will be received mainly from studies on economics, law and administration, and land-use

c) input will mainly be to those studies listed in b, above, especially economics and law and administration

4. No input to ERU mapping is anticipated.

5. The difficult problem of modeling sociological parameters will not be attempted in this study.

6. a) 2,000 man-hours

   b) 1,000 man-hours

7. An experienced Ph.D. level sociologist is required for this study. This person should be capable of pragmatic, non-academic analysis leading toward specific conclusions applicable to regional planning. During the initial stages of the study a research assistance, M. A. level, should be available.

8. a) 3 months

   b) none

   c) 5 months

   d) none

   e) 3 months

   f) 1 month

9. No special equipment is needed for this study.

10. No special technical support is required.

11. No monitoring is to be established as part of this study.

12. Social planning within the basin must be part of a coherent overall regional plan for development of the watershed. The environmental statement required by NEPA should clearly indicate that such planning exists, and that the environmental conditions effecting society as a whole are a factor which has been accounted for in programming basin management.

## PART 32: PROJECT PLANNING AND BASIN MANAGEMENT

1. Information required for this study includes:
   a) complete description of salient design characteristics of each project component, with consideration of direct costs and environmental costs
   b) summary and evaluation of planned project management programs, e.g. water quality control, water releases for purposes of flood control, maintenance of navigable channel, water supply, etc.
   c) evaluation of priorities assigned to various uses of the water resource, and to construction of various project components, with emphasis on environmental conditions that might alter these priorities
   d) evaluation of overall management structure for basin control, especially the effectiveness of the structure for maintaining basin quality at a high level
2. The primary activity will be to make an exhaustive analysis of basin studies held by Corps of Engineers, the Trinity River Authority Master Plan, and all related documents concerning project planning and basin management.

   This analysis should not be simply a review of what is known, but an objective consideration of the planning with recommendations for possible design modifications or changes in management structures. Modeling of management strategies can be used to determine recommendations

3. a) member of committees on Hydrophysical Environment and Project Design and Basin Management

   b) this study will obtain input from all other studies, especially those which reveal data on the nature of water resources and water-related resources within the basin

   c) all studies involving evaluation of project impacts will require information obtained by the BEEF research on project design and basin management

4. No input to ERU mapping is envisaged, but ERU characteristics are important in determining suitability of existing designs and plans.

5. Design components and management plans must be built in detail into the computer simulation models. Many management strategies can be modeled, to obtain the optimum plan.

6. a) 2,000 man-hours

   b) none

7. A high-level, experienced professional in water resources planning should be used in this study.

8. a) 2 months

   b) none

   c) 5 months

   d) 2 months

   e) 2 months

   f) 1 month

9. No special equipment is needed.

10. Copies of imagry, design specifications, and related data are needed for this study. Considerable computer time for input of project designs and management strategies should be allotted.

11. It is expected that authorities concerned with the Trinity River will continuously evaluate project designs and management programs.

12. In part this study represents an effort to obtain an outside opinion on the merits of the Trinity River Project, in order to insure that the environmental statement will achieve the goals of NEPA, that is i.e. will contain objective analyses that cannot be discredited by special interest groups who support or oppose the project.

## APPENDIX E.
## BEEF PERSONNEL AND LOGISTICAL SUPPORT

### Part I:
### BEEF Personnel

The requirements for BEEF personnel have been listed in Appendix D. In general, the specialists are expected to be persons with a high quality of training and experience in watershed studies, and able to communicate with fellow scientists. Selection of the personnel will be achieved through distribution of project grants, and through direct hiring for this environmental study.

The following table indicates the numbers of staff needed. Column one gives the reference number of the study, with general geology as number one, and so on. Column two indicates professional requirements, e.g., persons with a Ph.D., equivalent training. Column three indicates needs for technical personnel, from M.S. research assistants to field equipment technicians.

The numbers in the table given equivalent man-years of work required for the project.

| Study Number | Professional Staff | Technical Staff |
|---|---|---|
| 1 | 1/2 | 0 |
| 2 | 1 | 1/2 |
| 3 | 1 1/2 | 1 |

| Study Number | Professional Staff | Technical Staff |
| --- | --- | --- |
| 4 | 1 | 0 |
| 5 | 2 | 2 |
| 6 | 1 | 2 |
| 7 | 1/2 | 0 |
| 8 | 3 | 4 |
| 9 | 3/4 | 0 |
| 10 | 3/4 | 3/2 |
| 11 | 1 | 1 |
| 12 | 2 | 0 |
| 13 | 2 | 0 |
| 14 | 5/6 | 0 |
| 15 | 3 | 2 |
| 16 | 2 | 2 |
| 17 | 1 | 0 |
| 18 | 1 | 0 |
| 19 | 2/3 | 0 |
| 20 | 6/4 | 6/4 |
| 21 | 3/4 | 0 |
| 22 | 1/2 | 0 |
| 23 | 1/2 | 0 |
| 24 | 1/2 | 0 |

| Study Number | Professional Staff | Technical Staff |
|---|---|---|
| 25 | 1/2 | 0 |
| 26 | 1/2 | 0 |
| 27 | 2 | 0 |
| 28 | 2 | 0 |
| 29 | 3/4 | 0 |
| 30 | 1 | 1/2 |
| 31 | 1 | 1 |
| 32 | 1 | 0 |
| TOTAL | 38 | 19 |

## Part 2: Office Staff

One typist-clerk should be allotted for each five professional members of the BEEF team, or a total of eight typists for a period of one year. Additional work may be done by SCAT staff, or by temporary personnel.

If any BEEF studies are subcontracted, provision should be made for typing services in the ratio given above, i.e., one day per week per member of the professional staff.

## Part 3: Research Staff

Technical staff noted above are used for BEEF research.

Research staff utilized by SCAT personnel (see Appendix B) should be maintained and be available for BEEF research. No additional staff is required.

## Part 4: Laboratory Staff

Technical staff noted in Part I are used for laboratory analysis. In addition, the laboratory staff provided for SCAT will be expected to work full-time on BEEF problems, during the period of specialist studies. Major laboratory projects, such as Carbon-14 dating, will be subcontracted.

## Part 5: Field Staff

Technical staff noted in Part I may be used as field personnel. Occasionally, it may be necessary to hire additional laborers for specific projects, e.g., archaeological digs.

## Part 6: Cartographic Staff

Cartographic staff outlined in Appendix B should be sufficient for most work performed by the specialist task forces. Additional work, if needed, could be performed by the associated institution, by the Corps, or on a contract basis. Preparation of the final report maps will require formal printing services.

## Part 7: Computer Staff

All computer work done as part of the specialist research shall be included as part of the main computer studies, discussed in Appendix H.

## Part 8: Administrative Staff

Administrative structure developed for SCAT should be sufficient to carry through to BEEF.

## Part 9: Logistical Support

Additional logistical support is itemized under Appendix G. This support includes the provision of office space, remote sensing imagry, and field sampling equipment. In addition, there must be support during field-work, including transport with four-wheeled vehicles and/or boats.

## Part 10: BEEF Committees

In order to facilitate the interdisciplinary nature of the environmental studies, it is proposed that the Basin Environments Evaluation Force be organized informally into groups representing major sectors of environmental research. These groups or committees should establish procedures for communication among the members, including occasional meetings between all concerned. If any of the specialist studies are subcontracted, it is imperative that the professional staff of the subcontracted work be included in the committees, and fully participate in the exchange of information which is so vital to the successful completion of this research.

An example can be cited to show the type of information-exchange that is needed. Information from the study on transport will show traffic patterns for proposed barge routes, giving data needed for studies on air quality (barge exhausts), water quality (oil leaks, barge sewage), regional planning (industrial development), project management (water release needs), and many others. Similarly, the study on regional planning will produce data on conversion of rural land to suburbs, with resulting effects of importance to all studies of basin hydrology and ecology.

If each member of BEEF is required to work in a vacuum, obtaining all needed information without assistance, the proposed research will be time-consuming and incomplete. If full cooperation among the specialists can be achieved, the study of Trinity River Basin environments will be expedited, and will reach a high standard of accomplishment.

A possible framework for committee organization is as follows:

a) Committee on Hydrophysical Environment

Heads: SCAT Agronomist

SCAT Hydrogeologist

Members: General geology

Engineering geology

Geomorphology

Water balance hydrology

River hydrology

Stream sediment dynamics

Groundwater hydrology

Water quality

Climatology

Limnology (and oceanography)

Pedology

Agriculture

Forestry

Construction

Dredging

Project planning and basin management

b) Committee on Biological Environment and Land Use

Heads: SCAT Ecologist

SCAT Agronomist

Members: Geomorphology

Water balance hydrology

River hydrology

Water quality

Climatology

Limnology (and oceanography)

Pedology

Agriculture

Forestry

Terrestrial ecology

Aquatic ecology

Wildlife management

Fisheries management

Recreation

Water supply and use

Public health

c) Committee on Socio-Economic Environment

Heads: SCAT Economist

SCAT Ecologist

Members: Water quality

Air quality

Agriculture

Forestry

Wildlife management

Fisheries management

Recreation

Archaeology

Historical and scenic sites

Water supply and use

Public health

Regional planning

Economics

Transport

Law and administration

Sociology

d) Committee on Project Design & Basin Management

Heads: SCAT Hydrogeologist

SCAT Economist

Members: Engineering geology

River hydrology

Stream sediment dynamics

Water quality

Climatology

Air quality

Limnology (and oceanography)

Recreation

Water supply and use

Construction

Dredging

Waste disposal

Regional planning

Transport

Law and administration

Project planning and basin management

The existence of a framework, such as outlined above, is not meant to be rigid, and should not exclude further communication between specialists who are not members of the same committees.

## APPENDIX F:
## ORGANIZATION AND SCHEDULING OF ENVIRONMENTAL STUDY

### Part 1: P.E.R.T. Chart

Below is given a list of important activities which is of importance in completing the Trinity River Project environmental study, as planned in this report, and a list of landmark events which will indicate progress toward the tangible goal of the study: preparation of the environmental statement.

These activities and events are illustrated in a P.E.R.T. (Project Evaluation and Review Technique) chart. This chart can be used to monitor progress in the study, and to alter scheduling of activities as required.

A. A Listing of Activities from P.E.R.T. Chart for TRP Environmental Study

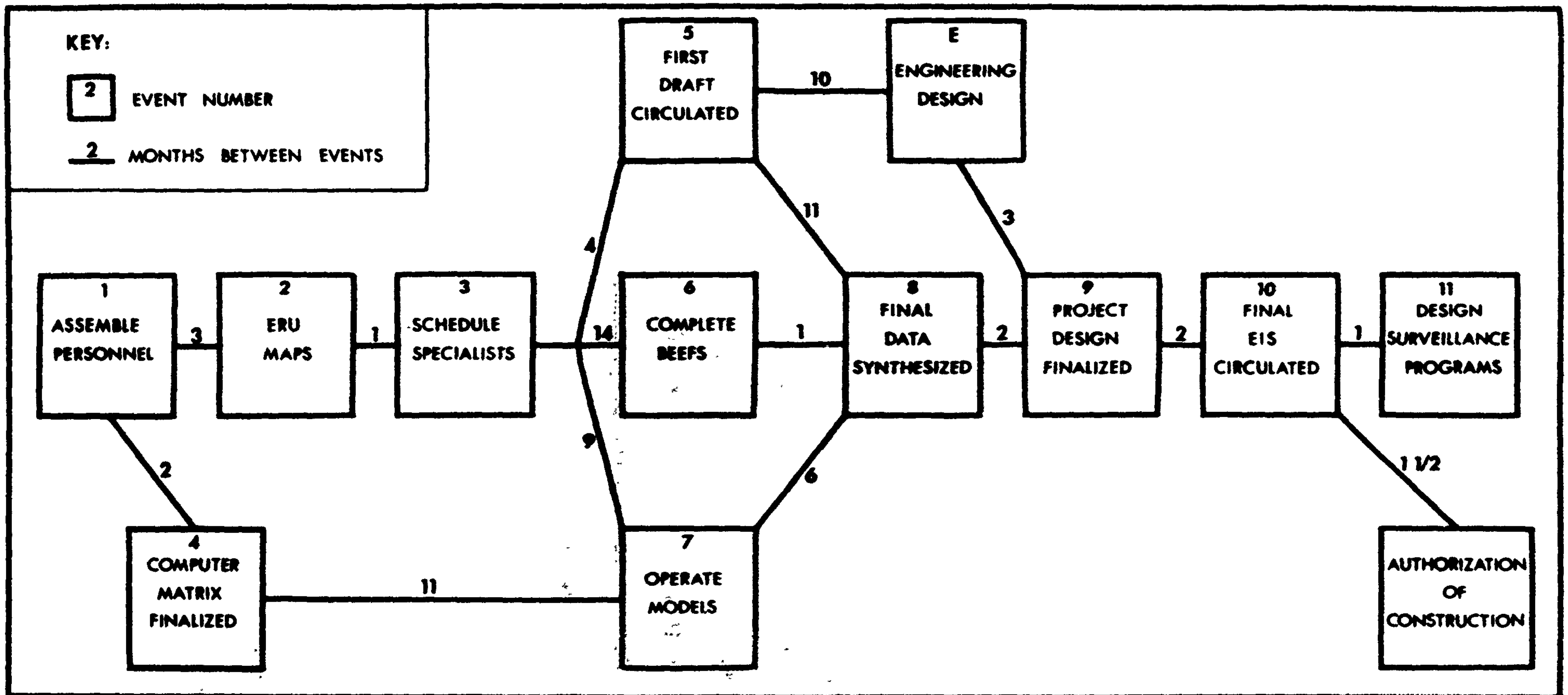
| No. | Description |
|---|---|
| 1-2 | Remote sensing and ERU mapping |
| 1-4 | Design computer data matrix |
| 2-3 | Review ERU maps; assign and schedule all BEEF work |
| 3-5 | Preparation of first draft of environmental impact statements |
| 3-6 | Conduct all BEEF work as assigned |
| 3-7 | Input from BEEF work to computer modeling efforts |
| 4-7 | Planning and programming of all computer models |
| 5-8 | Feedback from circulated first draft of Environmental Impact Statement |
| 5-E | Environmental impact of project concepts |

|  |  |
|---|---|
|  | circulated to engineering design groups |
| 6-8 | Synthesize all qualitative data and quantitative data not used in modeling, to assess environmental impact |
| 7-8 | Perform computer-simulations and synthesize, evaluate project impact |
| 8-E | Circulate preliminary reports to engineering design group |
| 8-9 (8-E-9) | Planning of final project design with all alternatives and their impacts in mind |
| E-9 | Synthesize input from all engineering studies |
| 9-10 | Compare final environmental impact statement with all project revisions/alternatives in mind |
| 10-11 | Design all monitoring programs for construction phase and long-term surveillance for basin management |

B. A Listing of Events from P.E.R.T. Chart for TRP Environmental Study

| No. | Description |
|---|---|
| 1 | Project is ready to begin with all personnel assembled |
| 2 | ERU maps completed |
| 3 | All tasks assigned to BEEF groups and scheduling completed |

| | |
|---|---|
| 4 | Design of computer matrix finalized |
| 5 | First draft of Environmental Impact Statement circulated |
| 6 | All BEEF tasks completed and reports submitted to SCAT |
| 7 | Computer simulations of various changes in basin are performed |
| 8 | All data from BEEF computer simulations synthesized and project impact evaluated |
| 9 | Designs of revised project plans are finalized |
| 10 | Final Environmental Impact Statement written and circulated |
| 11 | All monitoring surveillance programs are outlined and those for construction phase are implemented |
| E | Finalization of all preliminary engineering design aspects, accomodating where possible, mitigation of those concepts expressed in the preliminary Environmental Impact Statement |




PERT NETWORK FOR TRINITY RIVER PROJECT ENVIRONMENTAL STUDY

environment consultants, inc.

## PART 2: SCHEDULING OF PERSONNEL

The following pages contain charts showing scheduling of personnel required for SCAT, BEEF, and computer modeling research. The first chart indicates the activities of SCAT personnel, computer modeling staff, and the technical support crew. The number of persons engaged in each activity is specified.

The second chart indicates the activities of each BEEF study. The letters given in the chart refer to activities specified in Appendix D (pages D-1 to D-2).

## SCHEDULED ACTIVITIES AND PERSONNEL REQUIREMENTS FOR TRINITY RIVER PROJECT ENVIRONMENTAL STUDY

| Activity | MONTHS • LANDMARK | 1 - 3 ERU Maps Review Complete | 4 - 6 Specialist Work Begun | 7 - 9 Project Alternatives Studied | 10 - 12 Preliminary Impact Statement Complete | 13 - 15 Preliminary Computer Modeling Complete | 16 - 18 BEEF Complete | 19 - 21 Modeling Complete | 22 - 24 Environmental Statement Submitted |
|---|---|---|---|---|---|---|---|---|---|
| SCAT Field work | | 4 | | | | | | | |
| SCAT Supervise BEEF, Modeling project alts. | | | 4 | 4 | 4 | 4 | 2 | | |
| SCAT synthesis, final reports | | | | | | | 2 | 4 | 4 |
| Administration, Office Staff | | 2 | 6 | 10 | 10 | 10 | 10 | 2 | 2 |
| Literature, Data Research | | 4 | 4 | 2 | 2 | 2 | 2 | 1 | |
| Field Support cartography | | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| Computer matrix, modeling | | 2 | 4 | 4 | 4 | 4 | 2 | 2 | 1 |
| Computer programming | | 1 | 2 | 2 | 2 | 2 | 1 | 1 | |
| Data Reduction, digitizing | | 2 | 4 | 5 | 5 | 4 | 3 | 1 | |
| BEEF - Professional (summary of all work) | | | 40 | 44 | 44 | 33 | 26 | 6 | |
| BEEF - technicians | | | 20 | 22 | 22 | 8 | 17 | 8 | |
| LABORATORY lab personnel | | | 2 | 4 | 4 | 4 | 4 | 2 | |

## SCHEDULED ACTIVITIES FOR BEEF STUDIES

(letters refer to activities listed in Appendix D, pages D-1 & D-2)

| SPECIALIST ACTIVITY | MONTHS 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | a | a/b | b | c | c/d | d/f | | | | | | | | | |
| 2 | | a | a | b | b | b | b | c | c | d | d | e | f | | | |
| 3 | | a | b | b | b | b/a | c/b | d/b | b/c | d/d | e/f | e | f | | | |
| 4 | | a | a | a | b | c | c | d | d | d | d | e | f | | | |
| 5 * | | a/b | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | e | f | | | |
| 6 * | | a/b | c | c | c | c | c | c | d | d | e | e | f | | | |
| 7 | | | | | | | | a | a | b/c | c | d/e | e/f | | | |
| 8 * | a | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | c/d | e | f |
| 9 | | a | c | c | c | d | d | d | d | e/f | | | | | | |
| 10* | | | | | | a | b | c | c | c | d | d/e | e | f | | |
| 11 | | a | b | b | b | b | b | c | c | c/d | d/e | e | f | | | |
| 12 | | a | b | b | b | b | b | b | c | c | c/d | d/e | f | | | |
| 13 | | a | a | a | c | c | c | d | d | d | e | f | | | | |
| 14 | | | | a | a | b | b/c | c | c | c/d | d | e | f | | | |
| 15* | | a | b | b | b | b | b | c | c | d | d | e | f | | | |
| 16 | | a | b | b | b/c | c | c/d | d/b | b | b | c | d | e | f | | |
| 17 | | a | a | a | a | a | c | d | e | f | | | | | | |

* Technicians staff in field at all times

SCHEDULED ACTIVITIES FOR BEEF STUDIES, continued

(letters refer to activities listed in Appendix D, pages D-1 & D-2)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | a | c | c | c | c | c | d/e | e | e/f | | | |
| 19 | a | a | b | c | d/e | e/f | | | | | | |
| 20* | a | b | b | b | b | b | b | c | c | e | f | |
| 21 | a | a | b | b/c | c | c | e | e | f | | | |
| 22 | | a | a | c | c | d/e | e/f | | | | | |
| 23 | a | a/b | c | c | c/d | e/f | | | | | | |
| 24 | a | a/b | c | c | d/e | e/f | | | | | | |
| 25 | | a | a/c | c | c | d/e | e/f | | | | | |
| 26 | a | a | b/c | c | d/e | e/f | | | | | | |
| 27 | a | a | a | a | b | c | c | e | d | e | e | f |
| 28 | a | a | a | b | k | c | c | d | d | e | e | f |
| 29 | a | a | a | c | c | c | d | e | f | | | |
| 30 | a | c | c | c | c | c | c | c | c | c | c | f |
| 31 | a | a | a | c | c | c | c | c | e | e | e | f |
| 32 | a | c | c | c | c | c | d | d | e | e | f | f |

* Technicians staff in field at all times

## Part 3: Detailed chart of organization

- CORPS OF ENGINEERS / CITIZENS ADVISORY GROUP
  - CONSULTING ORGANIZATION
    - SCAT
      - TECHNICAL SUPPORT
        - Administration
        - Office Staff
        - Research
        - Laboratory
        - Field Staff
        - Cartography
      - BEEF
        - Hydrophysical Environment
        - Biological Environment
        - Socio-Economic Environment
        - Project Design
        - Basic Management
      - COMPUTER ANALYSIS
        - Modeling
        - Programming
        - Data Reduction

## APPENDIX G:
## LOGISTICAL SUPPORT

### Part 1: Field equipment

For field work by SCAT and BEEF personnel there are various items of equipment required. This equipment is that generally required for field work in the physical and biological sciences, plus the following:

a) field package for taking soil bores and field soils mechanics test (100 unit-days)

b) weirs and gauges for measuring runoff

c) weather station instrumentation, air sampling equipment

d) water sampling equipment, including probes and meters for measuring dissolved oxygen, conductivity, temperature, turbidity

e) Kemmerer (or Van Dorn) samplers; bottle samplers for suspended sediment

f) bottom corer (lake sediments)

g) plankton nets, sportsman trawls, productivity kits

h) surveying equipment, including alidades

### Part 2: Transportation

The following vehicle-time is required for SCAT and BEEF vehicle

a) 92 months for automobile or truck (maximum 14 vehicles at one time)

b) 62 vehicle-months for 4-wheel drive truck (jeep) (maximum 5 vehicles at one time)

c) 51 boat-months for small skiffs with outboard power (maximum 5 at one time)

d) 1 month helicopter transport (for SCAT team)

e) Air travel for personnel to visit government offices (e.g. Austin) and/or vital conferences

## Part 3: Laboratory equipment

Several different BEEF studies as well as SCAT will require extensive analysis of water (chemical), soil, and biological samples. Some analyses can be sub-contracted - e.g. Carbon -14 dating - but maximum efficiency and economy will be achieved if a lab is equiped with the following, and devotes full time to the environmental study.

Standard equipment, reagents, scales, glassware

DU spectrophotometer

Analytical Balance

Carbon Analyzer

Chlorine Titrator

ph meter

Atomic Absorption spectrometer

Ovens, drying cabinets, desiccators

Autoclave

Incubator, Refrigerator

Laboratory Press

Selves, Ro-Tap

Binocular and dissecting microscopes

BOD apparatus

Centrifuge, vacuum pump

Filtration system

Permeameter

Standard soil mechanics equipment

## Part 4: Imagry

During initial phases of the research (e.g. SCAT field work) existing imagry will be sufficient for the environmental study. As many as 15 BEEF studies will require air photos, and therefore, several copies of the photos are needed. Additionally at least five mirror stereoscopes should be provided.

Following the ERU mapping, a major inventory of basin environments should be obtained by flying special imagry: color infrared, black and white infrared, thermal, radar, multispectral, and other relevant sensors. Flight paths and scales will be determined by SCAT prior to commencement of BEEF work, and copies of imagry should be made available to all those who require them. In general, existing imagry will not be satisfactory, especially for the vital floodplain areas.

## Part 5: Administrative and other expenses

Budget arrangements should be made for provision of office space (150 square feet per person), office supplies, telephone, utility, and postage expenses, xeroxing, purchase of books and maps, costs of drafting equipment, expenses related to publication of the environmental statement, and other costs related to the functions of the study.

# APPENDIX H: TECHNICAL REQUIREMENTS FOR COMPUTER MODELING

As the computer modeling represents a primary component of this study, the technical requirements for the work are given here in some detail.

## Part 1: Personnel requirements

For purposes of this work four categories of personnel are needed: modelers, programers, digitizers, and statisticians.

To formulate the basic structure of the computer model will require professional scientists (Ph.D. level) familiar with systems approaches to environmental problems. Four such scientists will be needed, with specializations in systems hydrological, ecological, and economic modeling, with the fourth being a specialist in river basin management models. Each scientist should be experienced in their appropriate field, and already be familiar with some models appropriate for application to situations encountered in the Trinity Basin.

Much of the actual programming will be done by the professional staff mentioned above. However, program structuring and debugging can be facilitated by adding to the staff two programmers experienced in FORTRAN IV language of which one should be familiar with IBM 360 operating systems.

Digitization of basin information will require usage of map-digitizers, and keypunch machines. It is estimated that from 2 to 6 technicians will be required. Additional data, already computer ready, should be available from various government agencies.

Provision should be made for sub-contracting additional key-punching work if demand warrants.

Finally, to assist the specialist task forces in statistical analyses and in problem modeling, a statistician should be available during the period of the study.

## Part 2: Equipment and supply requirements

Provision should be made for access to an IBM 360 computer, model 60 or larger, with on-line plotter devices. Alternative computer configurations can be accepted, although the 360 is the unit most widely used by U.S. Government Agencies, such as the Environmental Protection Agency. Rental of six IBM model 29 keypunch machines, and 2 map digitizers is required. Two desk mini-computers (e.g. H-P model 9800) should be obtained. Finally, there will be need for purchase of computer cards and magnetic tapes as required.

## Part 3: Machine time

It is difficult to estimate accurately the amount of machine time required for full implementation of all modeling proposed in this report. For budgetary purposes, the large estimate of 200-250 hours is recommended.

## APPENDIX I: COST ESTIMATES

The following cost estimates are provided as an approximate guide to the budgeting requirements of the proposed environmental study. Actual contracting of the work will require a more detailed accounting of expenses. The estimates are based on the assumption that all of the work would be subcontracted by the Corps of Engineers to a consulting organization, such as Environment Consultants. Thus the budgetary experience of Environment Consultants, Inc. has been used to establish many of the estimates.

If the work is subcontracted to several different organizations the budget can be expected to enlarge somewhat, due to duplication of logistical and administrative expenses. It is recognized that the cost of the study may be met in many ways, e.g. by direct appropriation for the study, by allotment of funds within government agencies, or by special grants, (e.g. from Environment Protection Agency). It is further recognized that funds already alloted for environmental work in the Trinity Basin can be used to good effect in achieving the goals of the study plan, thus lowering the cost estimate given below.

Total budget needed for the research is under $2,400,000. This figure represents slightly more than 0.1% (one-tenth of one percent) of the budget for the Trinity River Project. The total expenditure will be less than twenty cents for each acre of the watershed. Thus the estimated cost of the study represents a modest expenditure designed to reap continuing environmental benefits.

| Salaries: | Personnel | Time | Salary level | Total Cost |
|---|---|---|---|---|
| | SCAT | 8 man-years | $20,000 | $ 160,000 |
| | Computer Professionals | 11 man-years | 12,000 | 132,000 |
| | BEEF Professionals | 38 man-years | 16,000 | 608,000 |
| | BEEF technicians | 19 man-years | 10,000 | 190,000 |
| | Other (Lab, office, research, cartography) | 40 man-years | 8,500 | 340,000 |
| | | | | $ 1,430,000 |
| Equipment (Appendix G) | Field Transport (rental, where possible) | vehicles | | $ 25,000 |
| | | four-wheeled | | 20,000 |
| | | boats | | 5,000 |
| | | helicopter | | 10,000 |
| | | air | | 10,000 |
| | Vehicle operation (400,000 miles) | | | 15,000 |
| | Field Equipment | | | 50,000 |
| | Lab Equipment | | | 25,000 |
| | Remote sensing imagry | | | 180,000 |
| | | | | $ 340,000 |
| Computer Expense | Machine Time | 200 hours | | 100,000 |
| | Peripherals | | | 35,000 |
| | | | | $ 135,000 |

| | | | |
|---|---|---|---|
| Logistical Support | Field time (meals, room) | $ | 100,000 |
| | Office Space | | 45,000 |
| | Office furniture, supplies | | 35,000 |
| | Telephone, postage, utilities, xerox | | 45,000 |
| | Purchase of books, maps, reports | | 10,000 |
| | Publication of reports | | 20,000 |
| | | $ | 255,000 |
| Supervision by Consultants | Monthly Consulting ($8,000) | | 192,000 |
| | Pre-study organization, study administration | | 40,000 |
| | | $ | 232,000 |

| | | |
|---|---|---|
| Salaries | $ | 1,430,000 |
| Equipment | | 340,000 |
| Computer Expense | | 135,000 |
| Logistical Support | | 255,000 |
| Supervision by Consultants | | 232,000 |
| | $ | 2,392,000 |

# APPENDIX J:
# LONG-TERM MONITORING AND SURVEILLANCE

It is anticipated that this study will provide a framework for continued monitoring of environmental conditions within the Trinity Basin. Data obtained from conventional sources, e.g. government agencies, should be added to the computer storage bank as it becomes available. In this way it will be possible to oversee environment dynamics throughout the entire basin, as a unit whole. The agency managing the basin, and/or their consultant, should maintain this monitoring. Advice on planning can come from the same source, with advice from members of SCAT, BEEF, and citizens advisory groups.

The study will establish new monitoring programs. These should be transferred to government agencies where possible, and maintained by special contracts elsewhere. The monitoring includes:

a) measurement of slope processes in key areas and channel conditions along key reaches

b) operation of new gauging stations

c) operation of new sediment sampling stations

d) operation of climatological stations

e) operation of water quality sampling stations

f) surveillance of land use changes, e.g. by updating of photo-coverage and remote sensing imagry

g) sampling of reservoirs and other water bodies affected by project

h) sampling of air quality in areas affected by project

i) surveillance of terrestrial and aquatic ecosystems affected by project

j) evaluation of progress in management of agriculture, forestry, wildlife, fisheries, recreation

k) surveillance to protect resources within basin, including archeological remains, historic and scenic sites, endangered species

l) review of basin management, with attention to environmental and socio-economic factors

## APPENDIX K:
## REFERENCES AND REPRINTS

This appendix contains reprints of:

Remarks by Lt. General Frederick J. Clarke, Chief, U.S. Army Corps of Engineers (quoted in <u>Trinity Valley Progress</u>, January-February, 1972, p. 25)

Wilson, Lee, 1968, Land Systems, <u>Encyclopedia of Geomorphology</u>, Reinhold Press, p. 641-644.
(N.B. when socio-economic considerations are added to the concept of a land system, the concept is then extended to include Environment Resource Units)

Additional references cited:

Brown, L.F., et al., 1971, Resource Capability Units, <u>Texas Bur. Econ. Geology Circular</u> 71-1, p.1.

Van Lopik, J., and Kolb, C., 1959, A technique for preparing desert terrain analogs, <u>U.S. Army Engineer Waterways Expt. Sta. Tech. Rept</u> 3-506, 70pp.

## PART I: REMARKS BY LT. GEN. FREDERICK J. CLARKE, CHIEF OF THE ARMY CORPS OF ENGINEERS

"The first lesson that comes through is that the environmental movement is strong, and is supported by strong legislation which is more apt to become stronger than to be weakened. I am not certain that this lesson is fully appreciated throughout the country, by some of the industries and by the organizations that push for development. One of the biggest errors that anyone could make today is to underestimate the power of the movement, and try to sweep a conflict under the rug. The courts have indicated that they interpret the laws to require a full environmental evaluation.

"A derivative lesson which is not so well understood has to do with what the Environmental Protection Act actually says, and does not say. It says that the environment must be considered -- honestly and as objectively as possible. It does not say that a project or proposal cannot go ahead if there are environmental disadvantages. But it does say that there shall be a full consideration of alternatives and mitigating measures before the decision is made to go ahead. The essence of the cases in the courts, perhaps not the intent of the plaintiffs, is that the planners of the development had not given to the environment the full consideration contemplated by the law. Nowhere have I seen in the court opinions, any direct attempt to take away from those so charged, the authority or the responsibility for making decisions.

"A third lesson that comes through very clearly leads to a current problem, and I suspect a problem which will plague us for many years. It has to do with the difficulties in defining what is important in the broad spectrum of environmental considerations. It is very easy to get enmeshed in cataloguing all of the flora and fauna, and in determining the ecological chains. But we are finding it much more difficult to spell out those matters which are of true importance or of such a unique character that they must bear special consideration. We have even found ourselves hoisted by our own petard when we have admitted that present day knowledge does not permit prediction of some results.

"We find a need for a professional ethic in the environmental field, so that the public can have a mechanism other than the courts to separate out the fringe elements, and have the benefit of the weight of opinion of professional environmentalists. Lacking this, we must find some mechanism whereby an appropriate group can provide authoritative guidance on what constitutes an adequate environmental analysis. This is not provided for in the present laws."

Part 3: Article from Encyclopedia of Geomorphology, 1968.

## LAND SYSTEMS

A *land system* is an area or group of areas with a recurring pattern of landforms, soils and vegetation. The concept of land systems was defined by Australian scientists engaged in reconnaissance land resource inventories (Christian and Stewart, 1953). Land systems have many uses but are particularly valuable (1) as units for summarizing and mapping resources, landforms, soils, vegetation, geology or any other feature of the earth's surface, and (2) as conceptual devices which achieve an integrated overview of the relationships between geologic and climatic history, landforms, soils, and ecology. Use (1) is primarily technical, i.e., land systems constitute a methodological tool which provides a relatively easy way of summarizing a vast amount of otherwise disparate information. Use (2) is primarily scientific, i.e., land systems are a conceptual device which requires a scientist to look at the landscape as an entity in which all components are interrelated.

Land system patterns are the result of three interacting controls (which are generally expressed on a scale suited to reconnaissance survey);

(1) Regional lithology and structure,
(2) Past and present regional climates,
(3) Geomorphic evolution.

The interaction of these three factors tends to give rise to a characteristic assemblage of landforms and soils, which in turn combine with climate to produce a typical pattern of natural vegetation (Fig. 1). The land system approach attempts to express the integration of all elements of the land complex, recognizing the causal links between them through an understanding of the *genesis* of the land system itself.

From a methodological point of view, the land system concept is essentially a synthetic approach to air photo interpretation. As Fig. 1 shows, close relationships exist between geology, geomorphology and vegetation. Field observations confirm that soil characteristics also can be related to air photo pattern. Standard techniques of air photo interpretation are used to delineate various areas of similar landforms and vegetation (i.e., to describe land systems). Field surveys are then made to determine the

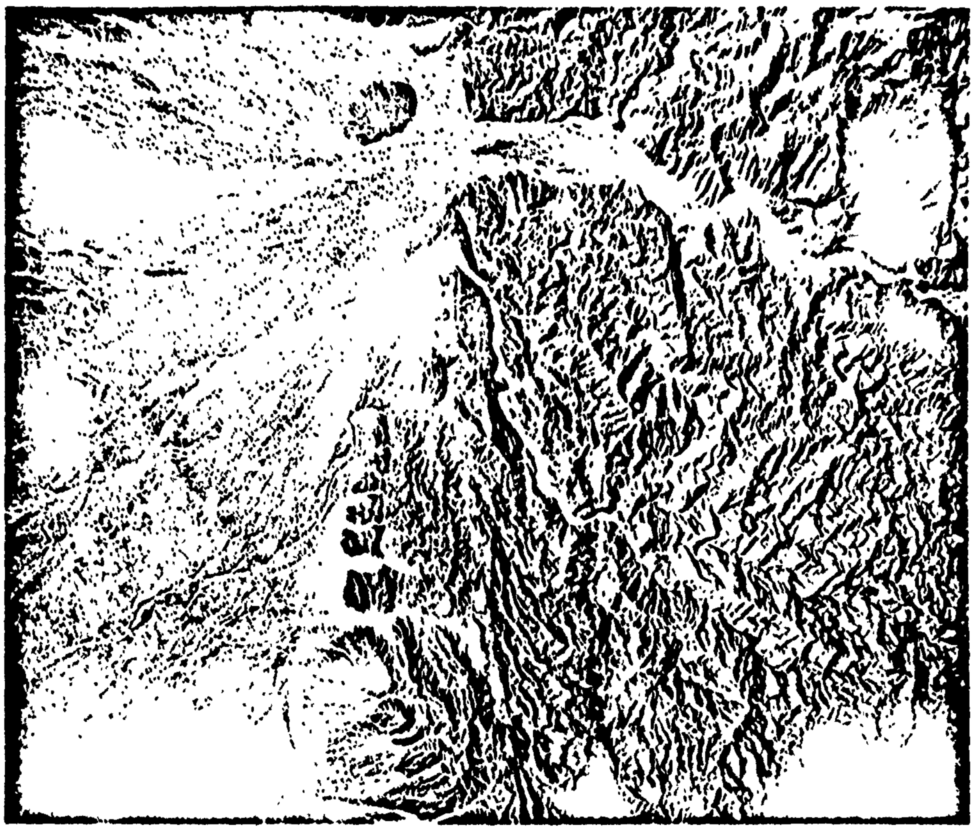


FIG. 1. Aerial photograph in Basin and Range Province, western United States. Two distinct land systems are shown: a mountainous terrain consisting mainly of erosional slopes with minor valley alluvium, and an alluvial fan terrain consisting of channels, interfluves and occasional inselbergs. Each land system is characterized by differing topography, vegetation, soils and history.

validity of land system mapping and to provide detailed descriptions of each land system. A report is published describing the general characteristics of the area mapped (climate, soils, vegetation, geology, geomorphology, agriculture, mineral resources and other data) and also providing summaries of characteristics of each land system (Fig. 2). A land system map is also published; this sheet is often accompanied by subsidiary maps showing geology, vegetation, soils, water resources, etc., for the entire area mapped. Such subsidiary maps are derived directly from the land system map by combining land systems which have similar geology, vegetation and so forth.

Difficulties in actually mapping and describing land systems occur. These often relate to the scale used in mapping, the fact that the mapped area may be very complicated, or to problems in correlating land surface characteristics with air photo patterns. However, once these problems are overcome, the final map and report provide an extremely useful summary of earth surface characteristics which is of value to many different scientific disciplines (geomorphology, ecology, and pedology, in particular), and to all those interested in analyzing and developing the resource potential of the area mapped [for a detailed description of this use of land system surveys, see Christian and Stewart (1964)].

As all ecologists (as well as many geographers, pedologists and some geologists) are aware, there is usually a very well-developed interrelationship between geologic and climatic history, bedrock, landforms, drainage, vegetation, soils and human activity. The concepts of the *ecosystem*, *soil catena*, *geographical cycle*, all illustrate this point.

The primary value of the land system approach to regional reconnaissance mapping is that it forces the mapper(s) to analyze *all* the factors which produce a given landscape and to integrate these factors. Thus, the forester can understand the distribution of trees in terms of slopes, drainage, soils and climate. For the geomorphologist, the great advantages of land system mapping are:

(1) Land system maps are geomorphic maps which, while not detailed, are very useful and relatively easy to make.

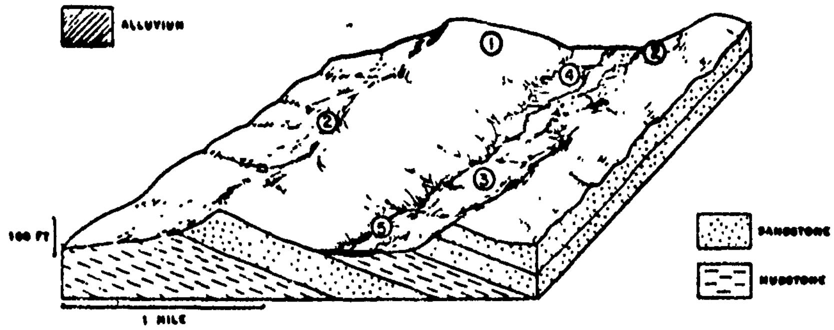
LYNNE LAND SYSTEM (250 SQ. MILES)

Stony plateaux with open mulga, in the centre and north-east of the area

**Geology.** Partly weathered, gently dipping Upper Proterozoic quartzite, sandstone, and feldspathic grit (Nullagine "system").

**Geomorphology.** Surfaces formed by dissection of the old plateaux—sandstone plateaux: strike belts up to 4 miles wide, with plateaux and bevelled ridges, rocky slopes, and narrow, flanking lowlands; occurring as parallel ridges separated by strike valleys with alluvial flood-plains, or as single ridges with a radial pattern of incised valleys; relief up to 150 ft.

**Land Use.** Hill pastures with stunted mulga shrubland: ephemeral growth in units 1–3 after rain should be stocked; palatable pastures in units 1 and 4 should be preserved by controlled stocking; drought resistance moderate; unit 4 subject to severe water and wind erosion; a little stock water in unit 4, but commonly saline.




| Unit | Approx. Area (sq. miles) | Land Form | Soil and Soil Association | Vegetation |
|---|---|---|---|---|
| 1 | 60 | Summits: up to 150 ft high, in strike belts up to 1 mile wide, gently sloping or rounded surfaces with slopes less than 5 %, very stony, with many rock outcrops | Outcrop and shallow stony soils Rock outcrop and 2 | Open mulga and other *Acacia* spp. with moderately dense inedible shrubs and palatable and unpalatable perennial grasses. *Acacia aneura* (mulga) sub-alliance (33) |
| 2 | 70 | Hill slopes mainly 5-20 %, with ledges and upper breakaways up to 20 ft high formed by quartzite or silicified strata, dissected into rounded spurs up to 50 ft high and ½ mile wide, with marginal slopes up to 15 % | | Stunted mulga with sparse shrubs, forbs, and short annual grasses: *A aneura* sub-alliance (29, 30) |
| 3 | 70 | Lower slopes concave, 0 5-3 5 % and mainly up to ½ mile long, stony surfaces with minor rock outcrops and extensive colluvial mantles, locally dissected to 5 ft | Shallow, stony soils on rock, locally on hard pan crusts. 4*b*. | As in unit 2, but increasing in density downslope |
| 4 | 30 | Flood plains and tributary alluvial drainage floors: up to 500 yd wide, gradients 1 in 250 to 1 in 1000; levees up to 1 ft high, with back slopes about 0 5 %, severely scalded surfaces with multiple shallow runnels, either throughout or in central zones up to 100 yd wide | No records, probably mainly texture-contrast soils 6*b* | Very sparse mulga with shrub layers of saltbush and bluebush and with forbs and succulents: *A aneura-Kochia pyramidata* (bluebush) alliance (60) |
| 5 | 20 | Channels, up to 50 ft wide and 5 ft deep | Bed-loads mainly sand, with low banks of pebble gravel | Dense fringing community of *Acacia* spp with some tall eucalypts and shrubs 72, also 60 |

FIG. 2. Tabular summary of the characteristics of the Lynne Land System, Western Australia [as published in C S I.R.O Land Research Series, No 7, (1963), Melbourne, Australia]. Note that general characteristics of the entire land system are given, including total area of system and land use A block diagram showing landform relationships and geology is included; in some land system descriptions, a geomorphic map replaces the block diagram Detailed descriptions of landform-vegetation-soil assemblages within the land system are also given References within these (e.g., 4b for the soil of unit 3) refer to more complete descriptions within the text of the published report Specific descriptions contain details commensurate with detail of real assemblages. In this example, the landforms are complicated and hence are described at some length, whereas the soils are relatively uncomplicated and are described very briefly.

(2) It is possible to relate closely different geomorphic aspects of the landscape (e.g., see Fig. 2) and to relate landforms to geologic and climatic controls.

A team of scientists is generally required to produce a land system map. The contribution of the geomorphologist to this team (Mabbutt and Stewart, 1963) includes. (1) analysis of *morphology*, i.e., relief, slope, drainage characteristics; (2) delineation of land systems on the basis of such geomorphic factors as a *common source*, such as lithology and structure in erosional land systems, or of a common formative process as in the case of flood plains; (3) determination of the *relative ages* of the land surfaces which make up the mapped area; (4) mapping on the basis of *landscape dynamics*, especially mode and rate of landscape change (e.g., stable versus active flood plains)

LEE WILSON